MINISTRY OF FUEL AND POWER

Domestic Fuel Policy

Report by the Fuel and Power Advisory Council

Presented by the Minister of Fuel and Power to Parliament
by Command of His Majesty
March 1946

LONDON
HIS MAJESTY'S STATIONERY OFFICE
ONE SHILLING NET

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FUEL AND POWER ADVISORY COUNCIL

DOMESTIC FUEL POLICY

To the Right Honourable Emanuel Shinwell, M.P.,
Minister of Fuel and Power.

PREFACE

SIR,

The Fuel and Power Advisory Council was appointed by the Minister of Fuel and Power to consider and advise upon questions referred to it from time to time by the Minister concerning the development and utilisation of the fuel and power resources of the country in the national interest. The membership of the Council is as follows:—

Sir Ernest Simon, LL.D., M.Inst.C.E., M.I.Mech.E. (Chairman).
Mr. Geoffrey Crowther.
Sir John Greenly, K.C.M.G., C.B.E., M.I.Mech.E., M.I.E.I., F.Inst.F.
Dr. E. S. Grumell, C.B.E., M.I.Min.E.
Sir Harold Hartley, K.C.V.O., C.B.E., M.C., F.R.S.
Professor C. N. Hinshelwood, F.R.S.
Professor John Jewkes, C.B.E.
Professor James Mackintosh, M.D., F.R.C.P., D.P.H.
Viscount Ridley, C.B.E.
Sir Robert Robinson, P.R.S., F.R.I.C.
Mr. Geoffrey Summers, C.B.E.

In view of the urgency of dealing with domestic heating matters owing to the Government's immense programme for the building of new houses, the Minister gave us the following as our first reference:—

"To consider and advise on the use of fuels and the provision of heat services in domestic and similar premises, in the interests of the occupants and of the nation, with special regard to the efficient use of fuel resources and to the prevention of atmospheric pollution."

We now have the honour to present our report on this reference.

We wish to express our indebtedness to Sir Alfred Egerton and his colleagues for their valuable report on Heating and Ventilation.* This report produced a mass of basic facts covering nearly all the scientific aspects of domestic heating and ventilation. The report was signed unanimously by a very representative committee of industrialists and scientists. Our report may be regarded as an attempt to indicate how the data given in the Egerton Report can best be applied in practice.

We are indebted to members of our Council who prepared Appendices to our Report. Professor James Mackintosh contributed the Appendices on "Smoke Abatement" and on "Comfort Requirements in the Home", the latter of which has influenced our recommendations on standards of heating.

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* Report on Heating and Ventilation (Ministry of Works Post-War Building Studies, No. 19) by the Heating and Ventilation (Reconstruction) Committee of the Building Research Board of the Department of Scientific and Industrial Research.
H.M. Stationery Office, 1946. Price 2s. 6d. (2s. 10d. including postage).

The Economists' Sub-Committee, Mr. Geoffrey Crowther and Professor John Jewkes, assisted by Mr. P. Chantler, one of our Assessors, contributed the Appendix on " Domestic Electricity Tariffs ", reaching conclusions on which we base our Chapter VII.

We are also indebted to our Secretary, Mr. R. E. L. Cleaver, who has been most helpful, and to the following Assessors, who have freely and fully placed at our disposal the knowledge and experience of their respective departments:—

Mr. P. Chantler (Economic Section, Cabinet Office).
Dr. A. Parker, F.R.I.C., M.I.Chem.E. (Director of Fuel Research, Department of Scientific and Industrial Research).
Mr. R. N. Quirk (Ministry of Fuel and Power).
Sir Reginald Stradling, C.B., M.C., F.R.S. (Chief Scientific Adviser, Ministry of Works).

I have the honour to be,
Sir,
Your obedient Servant,

E. D. Simon,
Chairman.

17th January, 1946.

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As regards cooking, the position is in general satisfactory. Suitable appliances are installed in most houses and they are adequately used. The weakest point is that many of the solid fuel appliances are extravagant and smoky. But when we come to the supply of hot water, the position is deplorable. Only a small proportion of the houses have a proper supply of hot water laid on to the sink and bath. In something like half the smaller houses hot water can only be obtained from a kettle. It is estimated that the amount of hot water used is on the average less than half of the minimum amount necessary for comfort, health and cleanliness.

Heat Services are costly

4. In spite of the gross inadequacy of the amount of heat provided, the average weekly expenditure of households of industrial workers, with incomes less than £250 per annum, on fuel, rent and rates in 1937-8 was as follows*:

	s.	d.
Rent and rates	10	10
Fuel	6	5

To obtain the heating standards we recommend with the old appliances would usually have been impossible. If it had been possible, it would at the prevailing working efficiencies and at pre-war fuel prices have cost at least 10s. a week: more than the cost of rent and rates combined in a large proportion of the smaller and older houses. The position is likely to be even more serious after the war. There is every prospect that the price of coal, and therefore of other coal-based fuels, will be greater in relation to the average industrial worker's income than was the case in pre-war days.

It is, therefore, abundantly evident that the cost of adequate heat services will inevitably be a very heavy burden for the lower income group households after the war. Indeed, with fuel at its present very high price, the majority of such households will be quite incapable of paying the cost of full heating services unless and until much more efficient appliances are installed.

Heat Services are inefficient

5. The open coal fire is a highly inefficient appliance. It has an average working efficiency of probably less than 20 per cent. In the United States†, in Sweden‡, and in Germany nearly all houses are fitted with some form of central heating plant, which keeps the whole house comfortably warm and has a working efficiency of from 40 per cent to 50 per cent. In all these countries the householder has to burn less than half the amount of coal needed by a British householder to secure an equivalent amount of useful heat in the house.

Heat Services pollute the atmosphere

6. We have been dealing so far with domestic heating as it affects the householder. Let us turn now to consider the point of view of the community as a whole.

The pall of smoke which does so much to make life in our great cities unpleasant, depressing and unhealthy is largely due to the domestic chimney. Over 80 per cent. of domestic heating is provided by burning bituminous coal mainly in the open coal grate or kitchen ranges. The open coal fire has always been the greatest sinner in smoke production; a substantial proportion of the coal is discharged into the atmosphere as soot and tar and sulphurous gases. It is estimated that domestic heating is responsible for about half the total smoke in the atmosphere.

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* Ministry of Labour Gazette, December, 1940, page 305.
† Appendix III, Section A.I.7.
‡ Appendix III, Section A.II.1.

Waste of national resources

7. Britain is poor in mineral resources with the single exception of coal, which is present in large quantities and of high quality.

Water power and indigenous oil are available on so small a scale as to be unimportant. It is not likely that these two taken together will, so long as the population remains about the present size, produce more than a small percentage of the fuel needed.

It is, therefore, of the utmost importance that we should not waste coal—that vital national resource on which our standard of living so largely depends.

We have shown that our coal is used for domestic heating with a degree of inefficiency which is not, so far as we can ascertain, even approached in any other country in the world. Quite apart from the resulting high cost to the householder this inefficiency causes a waste of many millions of tons of our coal reserves per annum. It has become fashionable to talk a good deal about the application of science and research to industry. In this case it is not a matter of discovering new methods; it is chiefly a matter of the effective application of remedies which are perfectly well known. It is vital that this lamentable state of affairs should be brought to an end without further delay.

8. To sum up, we are using excessive quantities of coal; we are providing inadequate heating in the houses; we are pouring out masses of soot and tar into the atmosphere.

In our view we cannot afford to maintain our low standards of heating; we cannot afford to continue to depress and destroy the life of our cities by smoke pollution; we cannot afford to waste our limited national coal reserves.

CHAPTER II

OBJECTIVES OF DOMESTIC FUEL POLICY

We have taken the following as our main objectives in framing a national domestic fuel policy.

(a) To ensure good standards of heating in the house.

By this we mean the provision of fuels and appliances of qualities and at prices that will enable householders in general to afford conditions of full health and comfort for all members of the household, with the minimum of dirt and labour.

The subject of comfort requirements in the home has been very carefully studied by Professor Mackintosh, and his conclusions are contained in Appendix III. Our recommendations on this subject are made in the light of his conclusions.

We accept as desirable the standards of space and water heating laid down in the Egerton Report (which we call the Egerton standards), as follows:—

Warming the house.—All the rooms should be capable of being kept continuously at a temperature of not less than 45-50° F. We call this " background heating ". In addition, facilities should be provided for " topping up " each room to a temperature ensuring full comfort.*

* See Egerton Report, Section 7.2.2.4.

Hot water should be laid on to the bath, basin and kitchen sink. Heating appliances should be capable of giving 250 gallons of water a week at 140° F.*

Cooking.—Efficient cooking facilities should be provided.

(b) Low cost and more convenience for the Householder.

To ensure that the heating installation and the fuels available shall be such as to enable the householder to secure the full Egerton standards, or at his choice a lower standard, at the lowest cost (including both capital and running costs).

(c) National Fuel Economy.

To ensure that all fuels shall be used in the most efficient and economical manner with due regard to the need for conserving the national reserves of coal.

(d) Smoke Abatement.

To abolish the pollution of the atmosphere from domestic sources by soot and tar, and to reduce to the lowest practicable limit the emission of sulphurous gases.

CHAPTER III

HEATING APPLIANCES FOR A SINGLE SMALL DWELLING

Coal Economy

1. In order to understand the problems of domestic heating it is necessary to have a clear idea of the different meanings of the word " efficiency " as applied to domestic heating appliances. Definitions of different kinds of efficiency are given in Appendix V.

We owe a considerable debt to the members of the Egerton Committee who have worked this matter out in detail. Those interested should refer to Chapter 6 of the Egerton Report.

The lay reader of our report need only concern himself with two conceptions of efficiency:

(*a*) The *working efficiency* of an appliance is the percentage of useful heat it gives the householder out of the fuel it consumes.

In the average open coal fire the working efficiency is about 20 per cent., the remaining 80 per cent. of the heat in the coal going to waste. In an electric fire the working efficiency is 100 per cent.

(*b*) The *coal economy efficiency* is the percentage of useful heat the householder gets out of the coal the nation has to provide for this service.

In the case of a coal-burning appliance coal economy efficiency is the same as working efficiency. In the case of gas, electricity or coke, coal economy efficiency is lower than working efficiency because of the loss of heat involved in converting coal into the other fuels. The following table† illustrates this:

	Working efficiency	*Coal Economy Efficiency for continuous space heating*
Coal fire	20	20
Gas fire	40	29
Electric fire ...	100	18

* See Egerton Report, Section 2.3.2.

† See Appendix I, Table VI

Gas and Electricity

2. Gas and electricity appliances were greatly improved in the inter-war years. Many manufacturers undertook research on a considerable and increasing scale and certain undertakings also established strong research departments, in contact with the daily experience and views of consumers. There was in some cases close co-operation between research organisations of manufacturers and of supply undertakings which contributed much to successful development. We may mention particularly the case of British gas and electric cookers which are probably the best in the world.

The manufacture of gas appliances was on a large scale: the rate of installation of all domestic gas appliances in this country during the few years immediately preceding the war averaged over 2 million annually, comprising over 1 million cookers, about half a million each of water heaters and room heaters, and several hundred thousand miscellaneous appliances such as refrigerators, etc. The large-scale manufacture of electrical appliances for the domestic market began later, but was expanding rapidly in the last inter-war years.

For intermittent heating electric and gas appliances offer great advantages in smokelessness, cleanliness, convenience and saving in labour, and in many instances the cost of fuel is less than for solid fuel appliances. For example, instantaneous gas water heaters give immediate hot water whenever it is wanted; and electric radiators have the advantage that they give forth immediate radiant heat and, provided suitable points are fitted, can be moved at a moment's notice to any desired spot.

Further improvements may be expected in the efficiency, reliability, convenience, cleanliness, flexibility and appearance of the various types of apparatus and in the direction of reduced maintenance charges. Progress in these various directions is likely to do much to determine the rates of expansion of the domestic use of gas and electricity.

Solid fuel. The open coal fire

3. Few applications of fuel are so wasteful of heat and so inadequate in result as room heating in this country by the open coal fire. But it has been and still is very popular. It is the traditional way of heating rooms; it gives a very pleasant warmth; it forms a social centre and adds to the pleasure of an evening's talk; it can be used to destroy refuse. Indeed, the open coal fire is a national institution.

It has the added advantage of being very cheap to instal, which is an extra inducement to the speculative builder to use it wherever possible; and coal has been so cheap in the past that, in spite of its very low efficiency, the cost of heating by the open coal fire has not been regarded as excessive.

On the other hand, the disadvantages of the open coal fire are great:

(*a*) The biggest single drawback is its low efficiency. The average efficiency of an open coal fire tended by an average housewife is estimated to be not more than 20 per cent. It is true that the efficiency under optimum conditions is considerably greater, but they cannot be maintained continuously.

(*b*) A coal fire entails labour in carrying the coal, in laying and tending the fire, and in cleaning out the fireplace and carrying ashes.

(*c*) It causes a good deal of dirt in the house, involving additional cleaning.

(*d*) The coal fire will only burn with a large flue of at least 50 sq. in.* This involves unnecessary draughts and discomfort.

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* See Egerton Report, Section 8.2.

(*e*) While it is true that the cost of the grate is small, the costs of the flue and of storage are considerable. It is estimated that in 1938 the cost of a flue for an open fire in a two-storey house was about £25, and the cost of storage for a ton of coal was about £5; and that the cost of amortisation and maintenance was 8d. weekly.*

These costs have in the past generally been assumed to be necessary costs and have not been debited against the cost of the coal fire.

(*f*) By far the greatest sinner in the emission of smoke and soot and tarry particles to the air is the open coal fire. There is no solution to the smoke problem of our cities till the old-fashioned open coal-grate is abolished.

To sum up, the coal fire is sociable and pleasant; but it involves dirt and drudgery for the housewife; it wastes millions of tons of coal each year, and is the chief sinner in rendering our cities unfit for human habitation by its smoke.

The open kitchen range

4. The following was written in 1922: †

"While there is much to be said in defence of the coal fire, nothing whatever can be urged in favour of the ordinary open kitchen grate. The total efficiency of the entire apparatus when it is all in use at the same time to its greatest capacity, including the hot water supply, hot plate and the oven, is usually about 7 per cent. It is, in fact, efficient only as a producer of vast and unnecessary quantities of smoke. And yet such ranges are still commonly fixed in new houses, even in housing schemes controlled by the Ministry of Health."

It is true that the old-fashioned kitchen range is now no longer being installed but many of them still exist.

Recent development in solid fuel appliances

5. Compared with gas and electricity, the development of scientific and efficient domestic appliances for burning solid fuel was almost a generation behindhand. It is only in recent years that really vigorous and large scale research and development work on solid fuel appliances has been undertaken.

6. There are to-day on the market, or in course of development, many types of efficient solid fuel space and water heating appliances suitable for the individual small house. The principal types are:

(*a*) *Open grates*—improved types as regards efficiency and ability to burn smokeless solid fuels as well as bituminous coal.

(*b*) *The closeable fire*—an open grate which can be closed for slow and economical combustion at night.

(*c*) *Openable stoves*—a closed stove of high efficiency which can be opened to give the effect of an open fire with reduced efficiency.

(*d*) *Closed stoves*—these are of the type of the well-known anthracite or coke stove.

(*e*) *Central heating appliances*—attempts are now being made with reasonable hope of success to develop these for single small houses.

7. The principal aims in designing these appliances are to secure:

(*a*) Accurate control of the rate of burning.

(*b*) High working efficiency.

(*c*) Continuous burning day and night, with a very low fuel consumption at night. This has the great advantage that the householder comes down to a warm room in the morning and has no fire to light.

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* Egerton Report, Table 7(6).

† "The Smokeless City", by E. D. Simon and M. Fitzgerald, p. 25.

(*d*) That the ashes can be easily and conveniently removed.

(*e*) That the appliances shall be of the multi-fuel type, capable of burning satisfactorily bituminous coal, anthracite and dry steam coal or coke.

(*f*) That when burning bituminous coal the emission of smoke shall be reduced to a minimum.

8. All these various appliances are frequently designed:

(*a*) To heat water as well as to warm the rooms, considerably adding to the efficiency and convenience. This seems to be the trend of present practice in low cost housing.

(*b*) To warm one or more rooms by " convected " air. This again adds substantially to the total efficiency and convenience.

9. There have also been considerable developments in the design of solid fuel cookers, the latest models of which incorporate many of the advantages hitherto confined to the expensive heat storage units. Cookers are becoming available that are much more economical and convenient than the old-fashioned kitchen range. They are insulated and are continuously burning so that service can be provided quickly in the mornings. Many of them are also fitted with water heaters that provide adequate hot water for a family of four or five.

Similar improvements are being made to the appliances, so popular in certain parts of the country, that provide for space-heating as well as cooking and water heating—the " combination grates " and " back-to-back grates." Although some improvements had already taken place before the war, for a number of reasons many of these appliances were inefficient; they burned large quantities of coal and they had to be relit every day. The appliances now going into production are designed to give much more accurate air control and to supply heat to the oven, to the back boiler or the room as required; they will incorporate closeable fires or openable stoves, so eliminating the daily relighting.

Efficiencies of the new solid fuel appliances

10. The new solid fuel appliances are still in a state of development; many of them have not been fully tested in practice. Further improvements are occurring very rapidly. It is therefore difficult to draw any definite conclusions as to the efficiencies that may be finally expected. The Egerton Committee summarised the best available information in Chapter 6 of their Report.

We have tried to make some estimate of the average working efficiency that may be expected from modern solid fuel appliances burning suitable smokeless solid fuels for combined space and water heating.

We are of opinion that it is reasonable to expect that the solid fuel appliances installed in new houses should have an average working efficiency of not less than 40 per cent.

We believe that as research and development proceed the average working efficiency might well approach 50 per cent.

Standards

11. It is important that appliances should be so far as practicable standardised, both to ensure good quality and to render possible large scale and therefore cheap production.

The British Standards Institution has already many standards, both dimensional and of performance, for heating appliances.

The B.S.I. is rendering valuable services. But standards are fixed by agreement with manufacturers, and in the interests of production compromises have been found necessary. Every effort must be made in the future to improve the standards in appliances for domestic heating.

Minimum standards should be established as soon as possible for all leading types of appliances. They should be laid down either by the B.S.I. or by such other body as is considered suitable and should be fully adequate to secure the required standards of efficiency and smoke reduction.

One danger of laying down standards is a tendency to rigidity and the risk of preventing progress. Minimum standards should therefore be reviewed at frequent intervals as research and development proceed.

We recommend that the manufacture and sale of new appliances falling below approved standards should be prohibited as soon as practicable.

Codes of Practice

12. The Codes of Practice Committee is working out British Standard Codes of Practice for the different aspects of heating, heat insulation and ventilation in houses. It is important that these codes should be completed as early as practicable and that they should be adhered to in all new houses whether built by local authorities or by private building owners.

We recommend that the Government should take steps to ensure that the codes of practice on heating and ventilation installations should be effectively adopted in all new houses.

Testing

13. The Government should provide a testing station, which must be independent of all sectional interests. The station should be responsible, in co-operation with trade associations, for the type testing of all types of appliances and reporting whether or not they comply with the approved standards.

The organisation of this work should be rapidly developed to enable it to be performed without causing delay to manufacturers in introducing new appliances.

Manufacture

14. It is important that the new improved appliances should be produced and sold at the lowest possible cost. This can only be done by large-scale production of standardised articles.

The organisation of the building industry is such that orders have in general been placed for a large variety of appliances in small numbers to suit the varied tastes and interests of building owners, architects, merchants and others. We believe that only the Government can secure the necessary conditions for large-scale manufacture and sale.

We recommend that the Government should take steps to secure the mass production of standardised domestic fuel appliances.

Appliances for the New Houses

15. The old coal grate and range were designed for burning bituminous coal and are not suitable for smokeless solid fuels. The inter-war appliances such as anthracite stoves and coke water heaters, designed to burn a specified smokeless solid fuel, are not suitable for burning bituminous coal.

It is now generally agreed that a good smokeless solid fuel has two advantages over bituminous coal:—

(*a*) While no smoke is produced from smokeless solid fuels, it is extremely difficult to burn bituminous coal completely smokelessly in any appliance designed for use in a single dwelling, though much can be done to reduce the smoke by better design.

(*b*) Solid fuel appliances, as a general rule, operate more efficiently with smokeless solid fuel than with bituminous coal.

It is therefore important as far as possible to substitute smokeless solid fuel for bituminous coal. Unfortunately, at present only small supplies of smokeless solid fuel are available. The right policy would therefore seem to be to produce multi-fuel appliances which will for the present burn bituminous coal as efficiently and smokelessly as possible; and can later on, when supplies become available, burn smokeless solid fuels.

Encouraging progress has been made. But in the development of such appliances many scientific and practical problems of great difficulty are involved, and there is still much scope for improvement. We regard further research and development in this matter as being of the first importance and urgency.

16. Modern efficient solid fuel appliances are more expensive than the open coal grate. In the past it has been common for building owners to instal inefficient appliances simply because they were cheap. This is in our view a disastrous policy because the waste of coal and the damage done by smoke far more than outweigh the initial cheapness of the appliances both from the point of view of the householder and of the nation.

In new houses where a subsidy is given the installation of approved multi-fuel heating appliances should be a condition of subsidy. Indeed, so far as the main solid fuel appliance is concerned, there is much to be said for a free issue by the Government as part of the subsidy. This would ensure the use of the best appliance and would enable the Government to secure the full advantages of standardisation and mass production.

17. **We recommend:**

(a) That the Government should encourage the production of improved heating appliances for all fuels and for all domestic purposes.

It is particularly important to develop multi-fuel appliances to burn efficiently and as smokelessly as possible both bituminous coal and smokeless solid fuels.

(b) That minimum standards should be established as soon as possible for all leading types of appliances.

(c) That the manufacture and sale of new appliances falling below approved standards should be prohibited as soon as practicable.

(d) That the Government should take steps to ensure that the codes of practice on heating and ventilation installations should be effectively adopted in all new houses.

(e) That the Government should be responsible for ensuring the proper type testing of appliances, and that the organisation should be rapidly developed to enable them to perform this work without causing delay to manufacturers in introducing new appliances.

(f) That the Government should take steps to secure the mass production of standardised domestic fuel appliances.

(g) That the Government should make every effort to secure the installation in all new houses of approved appliances for winter space and water heating to burn smokeless solid fuels or to burn bituminous coal with a minimum of smoke.

(h) That in subsidised houses the Government should make the use of approved solid fuel appliances a condition of subsidy, and should consider the advisability of a free issue of such appliances as part of the subsidy.

(j) That old-fashioned coal grates in existing houses should be replaced wherever practicable by new approved appliances. Subsidies should be granted by the Government to encourage widespread and rapid action on these lines. (See Chapter XIII, Section 4.)

CHAPTER IV

CENTRAL AND DISTRICT HEATING

1. In the last chapter we confined our discussion to appliances installed in a single small house. We proceed now to consider larger plants:

(*a*) Central heating plants for larger houses or for blocks of flats in a single building.

(*b*) District heating plants to supply heat to a number of buildings.

2. In both cases there is a single relatively large appliance, which can be designed to be more efficient than is possible for the single dwelling appliance. To achieve the highest degree of efficiency and smokelessness involves a large elaborate and expensive installation. The best example is the boiler plant of a great modern power station, which burns bituminous coal with a working efficiency up to 85% and an almost complete absence of smoke and grit. In certain cases special plant has been installed to wash out the sulphurous gas.

Such efficiency can only be obtained for domestic heating in large district heating plants. Such plants exist in America, where they are used to heat a number of large buildings where the density of the population is great. In Russia thermo-electric stations have been built on a large scale in new cities, to provide both electric power and heat. Russia has the advantage that it is the practice to insist on every building in the district accepting heat from the district heating plant, which would be difficult in this country.

From the point of view of efficiency and the smokeless burning of bituminous coal, these plants would be welcomed. But there are many complex economic problems involved, and it is uncertain how far they are practicable under the conditions of this country. A sub-committee of the Egerton Committee is studying the whole question of district heating, including combined thermal and electric schemes, and their Report must be awaited before action can be recommended in this matter.*

3. Central heating plants are the usual and the best means for heating blocks of flats or single large houses, and if well designed and worked are of high efficiency.

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* See Egerton Report, Section 6.2.3.h.

4. Suitable types of central heating plant can burn bituminous coal with an efficiency equal to that obtained from smokeless solid fuel, and with relatively little smoke; certainly very much less smoke per ton of coal than any single house appliance. Developments in domestic central heating plants should be encouraged, especially for the purpose of burning bituminous coal as efficiently and cheaply as possible.

5. One very important point is that the stokers should be competent and reliable. Stoking is a skilled job and careful selection and good training of stokers is vital. Before the war certain local authorities held courses for the training of stokers, and these have been greatly expanded in number by the Ministry of Fuel and Power in the course of the Fuel Efficiency campaign; special attention should be paid to the continuation of this educational work.

6. It is desirable that the available smokeless solid fuel should be used in the small houses and that suitable grades of bituminous coal should be provided for central heating and district heating plants that can consume such coal with the minimum emission of smoke. So far as practicable, the Government should use its influence in that direction.

7. **We recommend:**

(a) That central heating plants should be accepted as the main means of heating blocks of flats or single large houses.

(b) That the Government should endeavour to ensure that the available supplies of smokeless solid fuel should be burnt in individual houses, and that suitable types of central heating and district heating plants should burn bituminous coal.

(c) That suitable classes should be made available all over the country for training stokers.

CHAPTER V

THE DIVISION OF THE LOAD BETWEEN DIFFERENT FUELS

1.—(*a*) Good visual pictures for the different seasons of the year are given—

in Fig. I* of the amount of heat required for room heating, water heating, and cooking respectively;

in Fig. II* of the amount of heat obtained from coal, smokeless solid fuel, gas and electricity.

(*b*) We estimate that the total load in 1938 was divided as follows (Appendix I. Table III):—

	Per cent.
Solid Fuel	86
Gas	10
Electricity	4

(*c*) The domestic load in 1938 provided more than half the total market for the gas industry, and one-quarter for the electricity industry (Appendix I. Table II).

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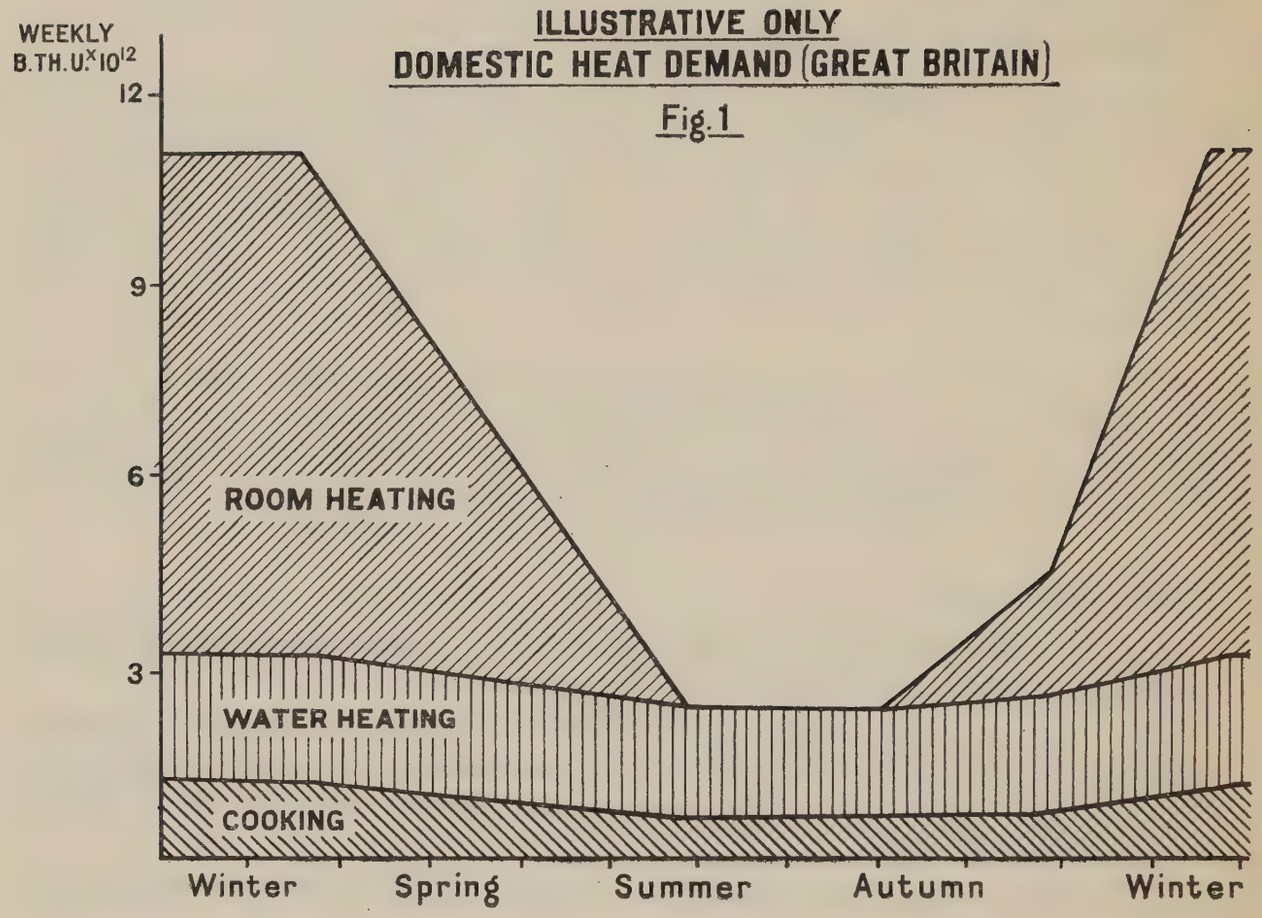
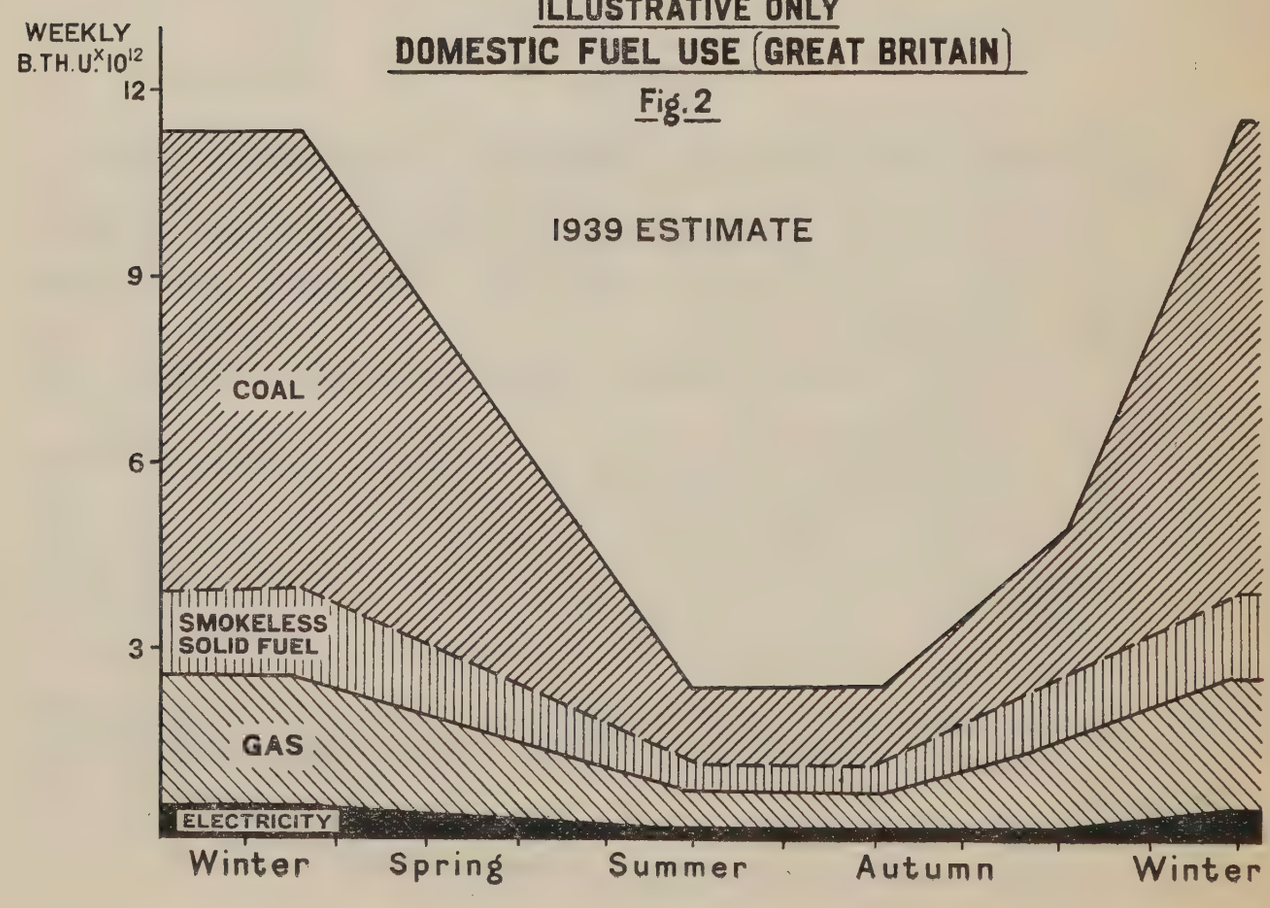
* We are indebted for these figures to the Gas Advisory Committee.



ILLUSTRATIVE ONLY
DOMESTIC HEAT DEMAND (GREAT BRITAIN)

Fig. 1



ILLUSTRATIVE ONLY
DOMESTIC FUEL USE (GREAT BRITAIN)

Fig. 2

Solid Fuel

2.—(*a*) While the load for cooking and water heating is fairly steady throughout the year, the load for room heating is heavy in the winter, and almost disappears in summer. This seasonal load is taken mainly by solid fuel; it would be economically impracticable for gas or electricity since it would involve a great extension of plant which would be idle in summer.

(*b*) Solid fuel burnt in efficient appliances for continuous heating of rooms or of water costs the householder about half as much as gas or electricity, and uses about half as much coal. It is becoming usual in low cost houses to provide a single solid fuel appliance for winter space and water heating.

(*c*) *Storage.*—Solid fuel has the further advantage that it can be stored in the house. This enables solid fuel to deal with the extra demand caused by a cold snap of several days without inconvenience.

Gas can be stored in holders at the works, but it is not economical to provide storage capacity for more than one to two days' supply. This enables the gas industry to maintain a steady output during the 24 hours irrespective of the variation in hourly demand. Whilst storage is a help in dealing with a prolonged cold spell, the greatly increased demand at such periods can only be met by the provision of special plant, held in readiness to meet such an emergency.

At present there is no practical method of storing electricity in large quantities.

Solid fuel storage is thus a means of saving the capital cost of expensive standby gas works and electricity plant. If arrangements could be made to store an average of one ton during the summer in every house, this would go a considerable way to evening out the winter and summer load on the coal mines, to the great economic advantage of the mining industry.

(*d*) For these reasons there is general agreement that the winter space and water heating load is likely, so far ahead as we can see, to continue to be taken by solid fuel. In our view this is to the interest both of the householder and of the nation.

Gas and Electricity

3. Gas now provides 10 per cent. of the useful heat in houses and electricity nearly 5 per cent.*, but during the last decade before the war the rate of increase for domestic sales for the two industries was approximately as follows: Gas 1½ per cent. per annum, Electricity 20 per cent. per annum.

Appendix I. Tables IVA and B give the best available estimates of the division of domestic heat services among the various fuels.

(*a*) *Cooking.*—Gas has secured a very large proportion of the cooking load. There are 9 million gas cookers installed and about 1¼ million electric cookers. This has been the field of the keenest competition. Electricity was gaining rapidly in the last years before the war and we have evidence that the electrical industry hopes to secure a large proportion of the cooking load in the next ten years.

It should however be remembered that solid fuel cookers of remarkable efficiency and convenience are now coming on the market, but they are expensive in initial cost. If cheap solid fuel cookers can be produced with these high qualities, gas and electricity will have to face very keen new competition.

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* Appendix I, Table III.

(*b*) *Water heating* by gas and electricity on a large scale is a relatively new development; gas now supplies about 15 per cent. of this load; electricity about 5 per cent.

The gas storage and instantaneous water heaters and the electric immersion heaters are exceedingly convenient, adaptable and popular. We believe water heating still offers a very wide field for expansion for gas and electricity.

(*c*) *Space heating.*—Gas and electricity are used mainly in the houses of the well-to-do for intermittent heating. The share of the market they have hitherto secured is very small and it is doubtful whether there is much prospect of great expansion among the lower income groups.

4. There can be little doubt that the use of electricity will continue to expand rapidly. As regards gas, the Heyworth Committee has reported*, after a thorough examination of the industry, " We have come to the conclusion that a reasonable forecast of the development of the Industry is that it will in ten years' time have increased its sales to at least 20 per cent. above the level of to-day [1945]."

The rate of increase in the use of the different fuels will depend on many factors, of which probably the most important are as follows:

(*a*) The skill and vigour of the managements of the solid fuel, gas and electricity industries respectively.

(*b*) In the large field where gas and electricity are more convenient but more expensive than solid fuel, much will depend on what the average householder can afford; this in turn will depend on the national standard of living.

(*c*) Much may depend on tariffs both in the gas and electricity industries.

The two-part tariff has become universal in the electricity industry. Every householder is willing to pay for electric lighting a charge which covers the overheads of connecting up the house for electricity; this makes it possible to sell current for other purposes at what is called a " commodity " price. Thus the price for lighting may be 4d. a unit, and for other purposes ½d.; a highly competitive figure. We deal with the problem of electrical tariffs in Chapter VII and Appendix IV.

Gas has no monopoly market comparable to electric lighting, and the introduction of a two-part tariff offers greater difficulties. Various attempts to do so have been made, and are continuing. The result cannot yet be foreseen; it may have an important effect on the competitive power of gas.

5. Gas and electricity have at present 15 per cent. of the total domestic market, largely won during the twenty inter-war years. We think it a reasonable guess that they may in another twenty years have captured a total of 30 per cent. of the market. Important technical developments, e.g. in connection with complete gasification of coal, the gas turbine, or even the use of atomic energy to generate electricity, might revolutionise the position.

6. Our conclusions as to the division of the load are as follows:

(*a*) The winter space and water heating load should be taken by solid fuel.

(*b*) Intermittent space and water heating for short periods should be taken by gas and electricity.

7. There remains a large field which should be left for free competition between the various fuels at the choice of the householder.

The two main fields of competition are likely to be:

(*a*) the cooking load;

(*b*) the spring, summer and autumn space and water heating load.

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* Report of the Committee of Enquiry into the Gas Industry, December, 1945 (Cmd. 6699), Section 209.

There are many days every year in every district in a moderate and variable climate like ours when it is doubtful whether or not it is worth while using the solid fuel heating appliance. The householder's decision will depend on the convenience and the cost of the services obtainable from the different appliances and fuels.

8. There remains the very important question of the division of the solid fuel load between bituminous coal and smokeless solid fuels. We have shown that for all appliances for the individual small house smokeless solid fuel burns more efficiently than bituminous coal, and that bituminous coal can never be burnt smokelessly in such appliances.

It is therefore of fundamental importance entirely to replace bituminous coal for use in the individual small house by smokeless fuels.

We recommend that it should be the policy of the Government to replace bituminous coal in all single house appliances by smokeless solid fuel as rapidly as adequate supplies can be provided at a reasonable price.

9. On the other hand, bituminous coal can of course be burnt as efficiently as smokeless solid fuels in suitable types of central and district heating plants, and often almost as smokelessly. It is therefore in the national interest to develop the smokeless burning of bituminous coal in these plants at least until sufficient smokeless fuels are available to supply the whole of the heat required in single dwelling appliances.

Rural Areas

10. In rural areas generally the space and water heating for the winter load might well be provided in the same way as in urban areas. Auxiliary heating can be by oil where gas and electricity are not available. Wood and peat will also clearly continue to be relied on.

Electricity should so far as practicable be extended to all districts.

We do not regard it as necessary or desirable that gas supply should be extended to the more thinly populated areas, except where it can be shown to be economically practicable.

11. We recommend:

(a) That the main winter space and water heating load should be taken by solid fuel.

(b) That intermittent space and water heating for short periods should be taken by gas and electricity.

(c) That subject to (a) and (b) the domestic heating field should be left for free competition between the main fuels.

(d) That it should be the policy of the Government to replace bituminous coal in all single house appliances by smokeless solid fuel as rapidly as adequate supplies and appliances can be provided at a reasonable price.

(e) That, even in thinly populated rural areas, the ultimate objective should be to lay on electricity to every house, so long as this does not throw excessive burdens on the consumers of electricity elsewhere.

CHAPTER VI

SOLID FUELS

1. By far the most important method of securing our objectives is the steady replacement of the 49 million tons of bituminous coal which were inefficiently burnt for domestic use in 1938 by smokeless fuels burnt with high efficiency, or by bituminous coal burnt in new appliances which render possible high efficiency and diminution of smoke.

Part of this load is likely to be taken by gas and electricity; the great bulk of it must be taken by smokeless solid fuels. To achieve this it is necessary that such fuels should be available in adequate quantities.

Is it possible to secure an additional supply—say about 20 million tons annually—of smokeless solid fuels of such qualities and at such prices that the householder will prefer them to bituminous coal?

2. Smokeless solid fuels are of the following types:

(*a*) Smokeless coals: anthracite, dry steam coal and other low volatile coals.

(*b*) Smokeless briquettes.

(*c*) Coke: including gas coke, hard coke from coke ovens and low temperature coke.

Anthracite and Dry Steam Coal

3. *Anthracite* has a high calorific value, and a high bulk density, so that it takes up less room than other fuels in store. It is less dirty to handle and readily keeps a stove burning all night.

It is an outstandingly good fuel when burnt in suitable appliances, and is much liked by most householders who have experience of it.

The price has been high, about £1 a ton above good household coal, and the consumption for domestic purposes has not exceeded 1.2 million tons per annum.

Dry steam coal is coal intermediate in respect of volatile matter and other characteristics between anthracite and ordinary bituminous coal and is a very suitable smokeless solid fuel.

Output of Anthracite and Dry Steam Coal.—We are advised that the reserves of anthracite and dry steam coal, mainly in South Wales, are very large, and that it should be possible to secure an increase of several million tons in the annual output from existing pits, provided that there is drastic reorganisation. Further increase in output would require the sinking of additional large modern pits.

We recognise that a rapid increase in the annual output may only be achieved after a transition period. Such an increase will involve important adjustments in house coal markets, but this should present no insuperable difficulty since they will be spread over a number of years. We of course appreciate also the paramount importance of the export market.

We recommend that the Ministry of Fuel and Power should take steps to secure a steady and rapid increase in the output of anthracite and dry steam coal.

Smokeless Briquettes

4. *Carbonised Smokeless Briquettes* are an admirable domestic fuel: smokeless, relatively clean to handle, consistent in size and quality, of high density, low ash content, and strongly resistant to damage by breakage and weather. They have only been introduced quite recently and on a moderate scale to the British market.

The supply of such briquettes should be encouraged and developed on the largest practicable scale, so long as they can be produced at reasonable prices.

Coke

5. *Gas coke* of properly graded sizes and when made from suitable coals and of regular quality, and burnt in suitable appliances (which should always be fitted with gas ignition), is an excellent domestic fuel which can be burnt with high efficiency. Its chief drawback is that owing to its low density it requires about twice the storage space of coal and a larger fuel bed in the appliance.

The history of gas coke in the London region is instructive. Thirty years ago the gas undertakings paid little attention to the quality of their coke: it was often bad and irregular; it was difficult to sell even at a very low figure.

In 1930 the London and Counties Coke Association undertook pioneering work to improve the position. They pursued three lines of action:

(*a*) Endeavouring to secure constant and high quality of coke;

(*b*) Designing and producing new and improved appliances;

(*c*) Developing an efficient sales and service organisation.

We are of opinion that the Association, though working only for a comparatively short period and with limited resources, succeeded to a substantial extent in the London area in these objectives. In particular they did much to foster the use of the coke hot water boiler, which was already a popular appliance for the middle income groups; the sales of coke were considerably increased.

The National Federation of Gas Coke Associations now co-ordinates Coke Associations covering the whole country.

6. *Hard coke,* made in coke ovens, has for many years been exported in large quantities (up to 1½ million tons per annum) mainly to Scandinavian and Baltic countries for domestic use. It is only in recent years that the sale of hard coke has developed for domestic purposes in this country; it is likely that considerable development will take place in the sale of hard coke for domestic purposes.

The British Coking Industry Association was formed at the beginning of the war, and has taken active steps to increase the sales of this coke for domestic purposes.

7. *Low Temperature Coke.*—This is an excellent domestic fuel, which burns pleasantly and efficiently in open grates or closed stoves. It has been sold in quantities of some half a million tons annually at prices well above those of good household coal. The difficulties in the way of extended production are mainly economic; it is to be hoped that these may be overcome.

8. *Supplies of Coke.*—The coal carbonisation industries carbonise annually about 40 million tons of coal and produce about 23 million tons of coke. Most of the coke from coke ovens is supplied to blast furnaces; most of the coke produced in gasworks is used for heating commercial buildings or for industrial purposes; only about 2½ million tons are burnt in domestic appliances.

We look forward to an expansion in the production of coke corresponding with the expected increase of 20 per cent. in the demand for gas in the next ten years*, and there is reason to hope that, when supplies of gas and coking coal become freely available and the wartime leeway in plant construction has been made up, larger supplies of both gasworks and coke-oven coke will become available for domestic purposes.

We are advised that there are ample resources in the country of carbonising coals to make a large expansion in the production of coke possible.

Quality of Smokeless Solid Fuels

9. If smokeless solid fuels are to be popular, it is essential that the quality should be good and regular. This involves two things:

(*a*) The highest possible proportion of the fuel supplies must be graded into sizes suitable for the various types of domestic appliances.

(*b*) Supplies of suitable coal or mixtures of coal must be ensured to the carbonising industries, and the coal must be specially cleaned at the collieries to reduce the ash to an economic minimum.

Although some fuels are satisfactory from both points of view, in the case of other fuels great improvements in these matters are still necessary. This is mainly a matter for the industries concerned, but it is important that encouragement and help should be given by the Government.

Importance of a Maintenance Service

10. Since increased supplies of smokeless solid fuels can only be made available gradually, the great bulk of the solid fuel will for many years consist of bituminous coal. It is to be hoped that the use of the latter will tend more and more to be confined to modern high efficiency appliances.

Solid fuel appliances, especially those designed for high efficiency, depend for good operation on draught control, prevention of air leaks (especially through fire doors), sound grates and sound fire brick backs. These items require regular maintenance, especially at the beginning of the heating season and before the onset of the sharp cold winter spells of January and February. If neglected, serious loss of efficiency occurs and any bad appliances are unusable at the time when they are most needed to meet the peak heating loads. An efficient maintenance service is, therefore, just as important for solid fuel whether smokeless or bituminous as it has proved to be for gas and electricity.

Sales and Service

11. During the inter-war years effective sales and service organisations were developed in the gas and electricity industries, and were largely responsible for their expansion. As we have shown, the solid fuel industries lagged far behind. But the London and Counties Coke Association and certain sales organisations for proprietary fuels showed that much could be done to make solid fuels popular with comparatively small effort and expense.

During the war the Solid Smokeless Fuels Federation has been formed to co-ordinate development between the three main producing industries; anthracite, gas coke, and hard coke.

The machinery now established to forward the development and use of smokeless solid fuels for domestic purposes seems to us to be on the right lines. It is to be hoped that its work will be energetically pursued and developed. We regard this as an essential factor for the steadily increasing domestic use of smokeless solid fuels.

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* See Chapter V, Section 4, above.

The Prospects of Expansion in Supplies of Smokeless Solid Fuels

12. Having regard to all these facts we believe that, after the post-war period of coal shortage and capital reconstruction, the supply of smokeless solid fuels of all kinds suitable for domestic purposes might be increased year by year at a rate of up to a million tons a year so that in 20 to 30 years the total increase might be up to 20 million tons. It is clear that this can only be achieved by vigorous and continued action by the Government with the support of the industries concerned and of public opinion.

By-Products of Carbonisation

13. Any considerable increase or decrease in the amount of coal carbonised would have important effects on the value to the national economy of the by-products, notably benzole, coal tar and their derivatives. In order to determine what these effects might be, we appointed a Sub-Committee under the Chairmanship of Sir Robert Robinson, now President of the Royal Society, to look into the matter, and their conclusions may be summarised very briefly as follows:—

The by-products of high temperature carbonisation (gas works and coke oven processes) are of great value. Their main outlets are subject to the balance of somewhat complex economic factors. The profitable disposal of a largely increased output of the bulk tar products might cause difficulty; but an uneconomic over-production of benzole seems most unlikely in view of its value as a motor fuel, where it replaces imported petrol, and its chemical uses. Some of the small tonnage by-products are essential for the well-being of important industries. In general, so far as by-products are concerned, a moderate expansion of carbonisation would be all to the good, a large expansion might create some disposal problems and a decline would have serious ill effects. As regards low temperature carbonisation a great increase at the expense of high temperature carbonisation would be undesirable, because of the greater value to the chemical industry of the by-products of high temperature carbonisation; on the other hand, a considerable increase in low temperature carbonisation would have the desirable effect of augmenting indigenous supplies of motor fuel, while any over-production of cresols which might result could probably be exported. In general it is considered that changes in the by-products equilibria will be gradual and that the chemical industry is sufficiently elastic to be able to accommodate itself to such tendencies.

The Cost of Coal

14. The cost of coal has increased to a serious extent during the war years and is now so high as to be a danger to the national standard of living and to our power to export. There is general agreement that reductions are urgently required both in the cost of production and in the cost of distribution. But this problem hardly comes within our present terms of reference.

It is of fundamental importance, however, for domestic heating that the cost of smokeless solid fuels and of anthracite in particular should be reasonable. We are advised that there are no valid technical reasons why the present cost of anthracite should be so much higher than that of other coal, and that large economies could be made by appropriate reorganisation.

15. **We recommend that the Government should:**

(a) encourage the largest practicable increase in the production of smokeless solid fuels suitable for domestic purposes;

(b) take active steps to secure a very large development in the supply of anthracite and dry steam coal;

(c) encourage improved and uniform quality and grading of smokeless solid fuels for domestic purposes;

(d) encourage the formation of an effective sales and maintenance organisation for the solid fuel industries;

(e) give serious attention to the reduction in the cost of all coal, and particularly of anthracite.

CHAPTER VII

GAS AND ELECTRICITY

1. The keen competition between gas and electricity in recent years has brought many advantages. It has led to increased activity in research and development. It has improved services to the consumer and has undoubtedly been an important influence in keeping prices down to the lowest levels consistent with reliable supply.

We regard keen competition of this kind as wholly salutary and, subject to one important condition referred to below, we think it should be allowed to continue. It is true that there are certain trends in fuel consumption which are desirable from the point of view of the householder and of the nation. The winter space and water heating load must continue to be taken by solid fuel. There is room for a large expansion in the use of both gas and electricity in the auxiliary services; notably in water heating. But there is no reason to believe that these desirable changes cannot be brought about by those responsible for the supply of each form of fuel seeking to provide the best possible service at the lowest possible prices.

2. All this, however, is subject to the condition that the prices charged for the various forms of fuel should be related as closely as possible to their cost of production and distribution. Cost is in the long run the most accurate, and indeed the only practicable, index of the resources needed to supply any particular commodity or service. Unless there are specific, recognised and accepted reasons to the contrary, it is bad economic policy for prices to be so out of line with costs that the consumer is encouraged to purchase goods or services at prices which do not cover the costs of the economic resources embodied in them.

3. Such a rule should apply to the prices of fuel, for if one form of fuel were consistently sold below cost this would be tantamount to the deliberate and wasteful immobilisation of the capital equipment created to supply some rival form.

4. The theory of the matter is relatively simple. It is much more difficult to apply in practice. For when, as is the case in gas and electricity (or even coalmining), a great deal of capital equipment is required before production can begin at all, the determination of the cost of any particular unit of gas or electricity involves a decision about the correct apportionment of the standing overhead costs in regard to which there may well be difference of opinion.

5. It was, indeed, suggested to us, in evidence, that the electricity supply industry, through the use of the two-part tariff, was responsible for unfair discrimination in its competition with the gas industry. Electricity has a

virtual monopoly for lighting. The allegation ran that relatively high prices were fixed for electric lighting and that, in consequence, low prices could be charged for electricity for cooking and heating, thus endangering the domestic market for gas for these purposes.

6. We do not feel that, as yet, there is sufficient firm evidence to reach a final conclusion on this highly intricate and controversial question.* There is certainly no evidence that, if any part of the electricity now being supplied for cooking or heating were discontinued, it would enable electricity for lighting to be sold at a lower price. And we accept the principle that it is in the national interest to dispose of off-peak electricity at low rates so long as these rates cover the additional costs incurred in producing the power. On the other hand it is clear that the virtual monopoly of lighting which the electricity supply undertakings possess should not be unreasonably used to secure an unduly high price for lighting, and we regard it as significant that in the United States the margins between the rates for electricity for light and for other purposes are narrower than in this country.

7. The issue would only be of practical importance if it should become clearly evident that the gas industry was suffering severely from this type of competition and, in fact, was threatened with decline or destruction. For, apart from the vital link which the gas industry constitutes in our war potential, it has an important part to play both in the production of valuable by-products and in the process by which, through the increased use of smokeless solid fuels, the problem of smoke pollution can be solved. But we are not convinced that, provided it follows a progressive policy, the future of the gas industry is seriously endangered. It will be remembered that the Heyworth Committee has forecast an increase of 20 per cent. in the sales of gas in the next ten years. The whole question, however, is one calling for careful and continuous scrutiny.

8. **We recommend:**

(a) That free competition should continue between gas and electricity for domestic heating, subject to the condition that the prices charged should be appropriately related to costs.

(b) That the outcome of the competition between gas and electricity and the influence exercised by the systems of tariffs upon the progress of the two industries should be kept under constant examination.

(c) That the Ministry of Fuel and Power should make arrangements for the collection of detailed statistics on this question.

CHAPTER VIII

OIL AND OTHER FUELS

1. Considerable use is made of paraffin oil (kerosene) for supplementary heating and cooking in rural areas where services for gas and electricity are not available or where the prices are relatively high. We envisage that with the provision of more efficient and attractive kerosene appliances use will continue to be made of this fuel for occasional and supplementary heating.

* For a detailed examination of this question, see Appendix IV.

2. There will also be scope for the extended use of oil for central heating and water heating. The number of oil-fired central heating plants in this country amounted to 4,500 in 1938 compared with nearly 2 million in U.S.A. While the cost of the plant is an important factor in the case of private houses, there are grounds for the encouragement of this method of heating larger premises such as blocks of flats, hotels and schools. If coal prices remain at their present level oil may come to play a bigger part in the heating of individual houses as well. Should the price of fuel oil remain low relatively to that of coal and should there be no tariff or foreign exchange difficulty to surmount, there is likely to be an increased demand for it for central heating purposes generally.*

3. Wood and peat constitute the main source of heat in a few outlying districts. They will continue to be preferred in many cases and will also be available for supplementary heating in rural areas generally.

4. Water power resources afford another potential source of heat. We do not regard a detailed examination of these resources, from which only 3 per cent. of the country's electric power is at present derived, as falling within the scope of this Report. Their development is unlikely to affect the price of electricity to the domestic consumer to any considerable degree.

CHAPTER IX

THE DESIGN OF THE HOUSE

1. All houses should be so built and equipped as to make it possible to provide the standards of heating which we have recommended at the lowest possible cost.

Insulation

2. It would be difficult to overstress the importance of conserving the heat produced in houses. Improvements in insulation, as the Egerton Report points out, will in general reduce both the fuel bill of the occupant and the amount of coal which has to be mined.

In our inconstant climate space heating is required at most times of the year intermittently rather than continuously. It is therefore essential to have ceiling and wall linings (of low " heat capacity ") which will enable a room to be warmed quickly, and to reduce heat losses by using materials of low " heat transmittance."

Hot water also is required intermittently, and it is of great importance that heat loss from cisterns and pipes should be reduced to a minimum by efficient lagging. Further research is needed on cheap methods of hot water storage.

Quite apart from the introduction of modern methods of insulation more attention should be paid to the common, everyday causes of undue heat loss: care should be taken in the construction of houses to provide well-fitting doors, windows, etc., in order to eliminate drafts. Heat ought to be conserved by having flues and other heat-carrying appliances removed as far as possible from the direct chilling effects of outside walls, and all pipes should be protected from frost.

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* The Liquid Fuel Installations Committee, convened at the Minister of Fuel and Power's request by the Institute of Petroleum, is reviewing the practice of installations for liquid fuel burning.

Flues

3. It is essential* that a flue suitable for a solid fuel appliance should be provided for the living room of each house. If an efficient appliance is used in the living room, supplying warm air by convection to one or more bedrooms, there is no need for brick flues in the bedrooms served. This gives a saving which may be offset against any increased cost of the more efficient appliance.

There is need for considerable further research on flue design.

Appliances

4. The building owner should supply an efficient modern solid fuel appliance or appliances:

(*a*) to provide the necessary heat for the living room and to provide by convection or by radiators the necessary background heating for the bedrooms;

(*b*) to heat the water;

(*c*) for cooking, in districts where no gas or electricity is available, and elsewhere if desired.

Auxiliary heating

5. Electric points should be provided in the main rooms; gas connections in the rooms with flues and in other rooms where gas is likely to be used.†

Storage

6. A store to contain between one and two tons of solid fuel should be provided for each dwelling.

Application to new and existing houses

7. Adherence to the above standards should be actively encouraged and as far as possible insisted on by the Government in new houses. Every effort should be made as opportunity offers to bring existing houses up to these standards.

8. **Recommendations:**

(a) All houses should be so built and equipped as to make it possible to provide the standards of heating which we have recommended at the lowest possible cost.

(b) The insulation of the walls and roof of the house and of the hot water system should be in accordance with the recommendations of the Egerton Report and of British Codes of Practice when adopted.

(c) A flue suitable for a solid fuel appliance should be provided in the living room, and the means for heating one bedroom by gas or electricity should further be provided.

(d) The building owner should supply an efficient solid fuel appliance or appliances.

(e) Electric points should be provided in the main rooms; gas connections in the rooms with flues and in other rooms where gas is likely to be used.

(f) A store to contain between one and two tons of solid fuel should be provided for each dwelling.

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* Except in cases where there are central or district heating installations.

† This would allow for use of a flueless gas heater, described in Appendix 7 to the Egerton Report.

CHAPTER X

THE HEATING INSTALLATION AND ITS COST

1. We regard the heating equipment which is now being installed by the Ministry of Works as a good example of the direction of development in the present stage of knowledge. Considerable improvements can be expected as research develops.

The following is a short description of modern equipment and the services it is designed to provide.

The most important appliance is the openable stove, burning solid fuel, for space heating and water heating. With suitable fuels it can be kept alight all night, burning not more than 1 lb. of fuel per hour. It heats the living room to a comfortable temperature and is highly efficient. It can be opened to give the sociability of an open fire, with some reduction in efficiency.

Air is heated by the stove and carried through ducts to the bedrooms. In winter it raises the temperature of these rooms by about 15° F.: it helps to prevent cold and damp, and the rooms can be quickly topped up to a comfortable temperature by gas or electric heater; they can therefore easily be used as bed-sitting rooms.

The stove is also capable of heating 250 gallons of water weekly to 140° F.

This stove supplies the background space heating and the water heating for the winter period. It may be lighted one or two days a week in summer to provide hot water for baths and clothes washing.

Equipment is provided to enable the householder to do the cooking, and the water heating and space heating in summer, by means of gas or electricity.

2. A particularly interesting development is the "Heat Service Unit" of the type which is now being tried out by the Ministry of Works. The unit consists of a self-supporting light steel framework enclosing the component parts. The following services are provided:—

(*a*) The solid fuel appliance, including a back boiler.

(*b*) A 30 gallon insulated hot water cylinder.

(*c*) A radiator to warm the drying cupboard and a duct to extract the warm damp air from it.

(*d*) Arrangements to supply warm air to the bedrooms.

(*e*) A panel gas fire at the first floor level with a separate gas flue, or alternatively an electric fire.

(*f*) A heated towel rail and linen coil.

(*g*) A gas or electric circulator, or electric immersion heater, may be installed to provide hot water during the summer months.

(*h*) Auxiliary ventilation of the kitchen and two bedrooms.

The Heat Service Unit is completely pre-fabricated at the factory; it is transported to the house and installed as a unit. The unit must be roughly in the centre of the house, and the architect must design the house round it. This is an important innovation and is likely to result in increased convenience to the householder and increased working efficiency.

Capital Cost

3. There are considerable economies in the construction of such a pre-fabricated heat unit through the elimination of unnecessary flues and the compactness of the whole design. When finally standardised, substantial

further economies should be possible by mass production. Although the cost of the modern solid fuel appliance must be more than that of the old appliances, it seems probable that the economies in the methods of installation may fully offset the additional cost of the solid fuel appliance. In that case it will be possible with a modern installation to secure the full Egerton standards of heating at a capital cost no greater than that of an average pre-war installation (present day prices being taken in both cases).

Running Costs

4. It is estimated that to achieve the full Egerton standards in the post-war 900 sq. ft. house will require about double the amount of useful heat provided in the average pre-war house occupied by families with an income of under £250.

Where the standard house has a heating installation on the lines we have described, it will under average conditions require during the year about three tons of solid fuel, and gas and electricity equivalent to another ton of coal, to achieve the full Egerton standards.

This is roughly about the same amount of coal as was consumed in the pre-war house. The difference is, of course, explained by the fact that the old installation had a working efficiency of 20 per cent. as against an average of 40 per cent. in the case of the new installation.

The householder may often decide for the sake of economy to be content with less than full Egerton standards. In that case the amount of fuel consumed will, of course, be reduced, though the efficiency is likely to be somewhat lower.

CHAPTER XI

RESEARCH

1. During the last generation effective research in relation to domestic heating has been carried out by various organisations and industrial undertakings, including:—

(*a*) The Fuel Research Station and Coal Survey Laboratories of the Department of Scientific and Industrial Research.

(*b*) The Building Research Station of the Department of Scientific and Industrial Research.

(*c*) The Gas Industry both co-operatively through a central research organisation and by some of the larger gas undertakings.

(*d*) The Electricity Industry co-operatively and by some of the electricity undertakings.

(*e*) Manufacturers of appliances for using solid fuel, gas and electricity.

(*f*) The Coal Industry and Combustion Appliance Manufacturers through a central research organisation.

2. In addition to the investigations undertaken by the Fuel Research Organisation and the Building Research Station of the Department of Scientific and Industrial Research, the Government has given substantial financial assistance and scientific and technical guidance to the co-operative research organisations established in recent years by the coal, gas, coke and electrical industries. Effective co-operation of the various research organisations is encouraged by the Consultative Conference on Fuel Research, under the chairmanship of Sir Harold Hartley, which was set up in 1943 by the

Department of Scientific and Industrial Research. The co-operative industrial research organisations concerned with fuel are all represented on this Consultative Conference.

3. Though much has been achieved as a result of the researches so far undertaken, and though there is now a large amount of fundamental scientific information, there must be considerable expansion of the research work in this field if the required rate of progress is to be achieved and maintained. It is in development work with the object of applying scientific and technical knowledge to the best advantage that progress has been particularly slow.

Expansion of the research and development work is urgently necessary in the next few years if our programme for adequate, efficient, economical and smokeless domestic heating is to be successfully carried out.

4. Some of the directions in which increased research and development work seem to us to be most urgently needed are as follows:—

(a) *Fuels.*

(i) Improved methods of cleaning coals to reduce their ash and sulphur content at reasonable cost.

(ii) Development of economical methods of producing coke and smokeless briquettes which are easily lit and kept burning at low rates of combustion.

(iii) Improved methods of breaking and size-grading coals and cokes to reduce the proportion of fine coal and coke produced.

(iv) Conversion of fine coal and coke into smokeless briquettes of a size and quality suitable for domestic appliances.

(b) *Appliances.*

To develop improved solid fuel appliances for space-heating, water-heating and cooking, which are:—

(i) easy to produce and instal at reasonable cost,

(ii) simple to operate, with easy adjustment of the distribution of the heat between space and water heating and cooking to meet the varied requirements, and with a low minimum rate of burning to allow of continuous operation economically,

(iii) suitable for use with several types of solid fuel and producing little or no smoke,

(iv) of high efficiency,

(v) of pleasing appearance.

(c) *Houses.*

To improve the construction of houses and the installation of the heating equipment generally with the objects of:—

(i) reducing the loss of heat to the atmosphere,

(ii) providing adequate but not excessive ventilation and good conditions of comfort.

(d) *Sociological.*

Only by large-scale experiments under the best conditions can many of the problems which have come before us find a satisfactory solution. We should therefore welcome far-reaching investigations, including those which we understand the Ministry of Works propose to undertake.

We recommend that the modes of living of different families in houses of different design and with different combinations of heating appliances should be studied by scientific observers on a large scale over a period of years.

5. The researches of private enterprise should be co-ordinated as far as possible with the longer range work of the Government Research Stations and the Research Associations.

6. **We recommend—**

(a) that expansion of research and development is urgently necessary in the next few years if our programme for adequate, efficient, economical and smokeless domestic heating is to be successfully carried out.

(b) that large scale user trials should be undertaken by the Government.

Chapter XII

INFORMATION, EDUCATION AND SERVICE

1. Service and maintenance organisations exist on a large scale in the gas and electricity industries and on a small scale in sections of the solid fuel industries. The new solid fuel appliances tend to be complex, and we have recommended that an effective service and maintenance organisation should be developed for solid fuels throughout the country, because we regard such an organisation as essential to the efficient working of these appliances. But this is not enough; it is also necessary that impartial information should be available as to the best type of installation in different kinds of houses and that there should be a widespread system of education for the house-wife in the use of these appliances.

Government Information Service

2. The problems of finding the right fuel and the right appliance for any given purpose and the right combination of appliances for the house as a whole are complex and difficult, and are constantly changing as research and development proceed. There is at present no centre where building owners, heating engineers and architects can get authoritative information and advice on these matters independent of any special interest.

We recommend that the Government should establish centres in London and in principal cities in the regions where examples of all the most suitable types of appliances should be shown. There should be a staff of engineers, architects and scientists with full knowledge of all the aspects of domestic heating, and in close touch with the Fuel Research Station and all other research and development organisations.

The staff in these centres should be responsible for advising building owners and architects and for giving the necessary information and help to local authorities in their region to enable them to advise local building owners and householders.

This staff should advise on—

the most suitable appliances and combinations of appliances;

the most suitable fuels;

the best design of flues, ventilation, insulation, and methods of installation.

The advice given could take into account not only the interests of the householder as regards costs, convenience and efficiency, but also social values such as the abatement of smoke and the conservation of national fuel resources.

The Housewife

3. Much depends on the skill with which the housewife manages her heating appliances. This applies particularly to cooking and to the new combined solid fuel appliances. The Fuel Efficiency Directorate of the Ministry of Fuel and Power has made a useful beginning in educating housewives by pamphlets, lectures, conferences and demonstrations. This work should be continued and developed.

4. **Recommendations:**

(a) The Government should establish information centres in London and in principal cities in the regions, with skilled staffs of heating engineers, architects and scientists, and with showrooms, where examples of all the best types of appliances could be seen.

(b) The work of the Fuel Efficiency Directorate of the Ministry of Fuel and Power in educating housewives should be continued and developed.

CHAPTER XIII

SMOKE ABATEMENT

1. One of the matters which we have had most constantly in mind in considering the subject of domestic heating has been how to abate the smoke which issues from domestic chimneys. The grievous damage done to buildings, plants and above all to human beings by the pall of smoke which so often hangs over our great cities is due in large measure to the domestic chimney.

The latest authoritative facts in this matter are given in Appendix II by Professor Mackintosh. We confine ourselves here to the steps which we recommend in order to reduce and ultimately to abolish the domestic smoke nuisance.

2. By a most fortunate coincidence the steps which we have recommended, mainly for the purposes of securing economy, convenience and cleanliness for the householder, are almost identical with the best practicable steps to secure the reduction and eventual abolition of the smoke nuisance.

Smoke is due to the burning of bituminous coal. Our two main lines of reform are:

(*a*) To replace bituminous coal by smokeless fuels: smokeless solid fuel, gas or electricity. If and when that process is completed domestic smoke will be abolished. Meanwhile, we have recommended that the available surplus of smokeless solid fuels shall be mainly absorbed in the new houses. Comparatively small amounts will therefore be available for increased use in existing houses. These problems have already been fully dealt with in earlier sections of the report and there is no need to discuss them further here.

(*b*) The process must necessarily be a slow one; we have estimated that it will not be possible to produce the necessary amount of smokeless solid fuels for twenty, or perhaps thirty, years. Our second main line of reform is therefore to instal improved appliances to burn bituminous coal with the minimum of smoke.

3. The smaller the appliances the more difficult it is to burn bituminous coal smokelessly. Smokeless solid fuels should therefore so far as practicable be consumed in domestic appliances. Suitable types of central heating and district heating plants should in general burn bituminous coal. Every effort should be made to ensure smokelessness of these plants by improved design of appliances and by the training of stokers. The local authorities should instruct their smoke inspectors to pay special attention to these plants. Another important point is that the stokers should be well trained, to ensure not only efficiency but also the minimum emission of smoke.

4. The most difficult problem is the reduction of smoke when burning bituminous coal in a single house appliance which must necessarily be cheap and simple. It is encouraging that new types of appliances are being developed which substantially reduce the emission of smoke as against the old-fashioned coal grate. Some of these appliances will burn not only bituminous coal but also most types of smokeless solid fuel. They can therefore be used for the present with bituminous coal, though with some sacrifice in efficiency and cleanliness; and can be turned over to smokeless solid fuel when supplies become available.

These appliances unfortunately must cost more than the old coal grate; in new houses there is every hope that this additional cost will be offset by better and cheaper design of the heating installation as a whole. **It is, moreover, desirable that appliances of this type should be substituted on a large scale for the old-fashioned coal grate in existing houses.** Since they are much more efficient than the old coal grate, this will offer substantial advantages to the householders, both in providing more heat and in lower running costs. On the other hand, the cost of the appliance and of its installation will be substantial, and **we recommend that the Government, in the interests both of smoke abatement and of national fuel economy, should grant a subsidy to ensure the installation of these new grates in place of old ones on the largest practicable scale.***

5. So far we have dealt with smoke. The problem of preventing the emission of sulphurous gases is far more difficult. Indeed, there is no practical way of preventing it. But the amount can be reduced in the following ways:—

(*a*) The installation of more efficient appliances will result in a reduction of the amount of fuel burnt and therefore in the amount of sulphurous gases emitted.

(*b*) So far as practicable all coal should be cleaned before being used for domestic heating purposes. This should to some extent reduce the sulphur content.

(*c*) The increased use of gas and electricity will cause a reduction in the emission of sulphurous gases in the larger centres of population.

Smokeless Zones

6. The National Smoke Abatement Society has in recent years pressed for the establishment of smokeless zones†, in which it shall be an offence to discharge into the air any smoke whatever. Smoke does most harm in the large cities, and it may well be worth a special effort to clear up the atmosphere of these cities by the use of smokeless fuels and by strict control over the emission of smoke even if this leaves less smokeless fuels available for the remainder of the country.

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* Chapter III, Section 17 (*j*).

† See " Smokeless Zones " published by the Smoke Abatement Society, Chandos House, Westminster, S.W.1.

7. We describe in Appendix II a remarkable example of effective action on these lines by the City of St. Louis in the United States of America. It is a large industrial city which in 1940 was one of the most notoriously smoky cities in the United States. By action on the lines described in the Appendix, St. Louis has been converted in two years from one of the dirtiest towns in the United States to an exceptionally clean one. No serious hardship has been imposed on anybody; the work of the Smoke Commissioner has been generally welcomed and is to-day widely and strongly supported.

This is in our view the most effective and successful action which has ever been taken in the abatement of smoke in a single city.

8. In considering how far it would be wise to follow the example of St. Louis in this country, we must bear in mind one important difference between American and British conditions:—

St. Louis uses almost exclusively some form of central heating; it has practically no open coal fires. To make a smokeless zone effective in this country, it would be necessary to replace the existing old-fashioned coal grates by new appliances capable of burning smokeless fuels. This would be an expensive process.

9. We have already shown that all the available smokeless solid fuels are likely to be needed for the new houses during the next few years. There will also undoubtedly be an increasing demand for such fuels from existing houses. When the supply of smokeless solid fuels has been substantially increased it might well be desirable to make a national plan for using the maximum proportion of smokeless solid fuels in the large cities where smoke does most damage and the declaration of large smokeless zones might be one of the best methods of securing this result.

Meanwhile we are of opinion that in order to gain experience it would be desirable to declare a few smokeless zones of different kinds. For instance one or two complete towns might consider the possibility of following the example of St. Louis; any new towns built should certainly be made smokeless from the start; one or two cities might try the experiment of declaring a selected district in the city as a smokeless zone.

Such zones should be chosen by the Local Authority and approved by the Government.

10. Legislation will be required to render possible the establishment of smokeless zones. It should be so widely drawn as to enable the Local Authority to use whatever means may prove effective for securing smokelessness. These should include:—

(*a*) Power to insist on the exclusive use of smokeless solid fuels except in approved appliances;

(*b*) Power to insist on the installation of approved appliances for central heating capable of burning bituminous coal with very little smoke emission;

(*c*) Power to make it an offence to emit smoke.

Apart from compulsory methods, it would be essential to educate public opinion to support the effective enforcement of smokelessness, and to help those responsible for furnaces to work them on the best lines by regular visits from experienced and skilled inspectors. The intensive training of stokers would also be an important point.

11. **Recommendation:**

The necessary legislation should be passed to enable smokeless zones to be established, and a few such zones should be declared, mainly for experimental purposes.

12. If the recommendations of our report are effectively carried out domestic smoke will steadily decrease and virtually disappear in from 20 to 30 years. That means the abolition of half the smoke; this is particularly important because domestic smoke contains sticky unburnt tar and therefore does more damage than industrial smoke.

If, meanwhile, industrial smoke is tackled with more vigour, we are confident that the smoke nuisance can be virtually ended in from 20 to 30 years.

Chapter XIV

A LONG-TERM PROGRAMME

There are three main lines of development in our programme for efficient, convenient and smokeless domestic heating.

1. The most important is progressively to replace the bulk of the bituminous coal now burnt by some smokeless solid fuel—anthracite, other low volatile coal, gas coke, hard coke, low temperature coke or smokeless briquettes. These fuels should ultimately take the bulk of the winter space and water heating load with an average working efficiency of not less than 40 per cent.

The late Government's programme was to build some 400,000 houses a year for the next ten years. If these were all fitted with efficient space and water heating appliances as we recommend, and if each of them burned $2\frac{1}{2}$ tons of smokeless solid fuel per annum, this would mean a demand for an additional million tons of smokeless solid fuel each year. We are of opinion that this is the maximum annual increase in the output of smokeless solid fuel which is likely to be practicable.

2. The second line of attack (to achieve convenience in use at some sacrifice of coal economy efficiency) is to increase the use of gas and electricity. Householders should be given every practicable opportunity of using gas and electricity, and the industries should be encouraged to endeavour to secure an increasing share of the domestic load. About 15 per cent. of the useful heat in houses is now provided by gas and electricity. Much the greater part of this important development occurred in the 20 inter-war wars. We regard it as a reasonable guess that at the end of another 20 years gas and electricity together may provide up to 30 per cent. of the useful heat in houses.

3. The third line of attack is to burn bituminous coal with increased efficiency and with the minimum emission of smoke:

(*a*) in central and district heating installations;
(*b*) in improved appliances in separate dwellings.

4. How soon may we hope that our programme of efficient and smokeless heating will be completed? It is impossible to make any accurate forecast because it depends on so many uncertain factors:—

(*a*) On the number of new houses built and on their size, design, insulation and ventilation.

(*b*) On the number of modern heating appliances installed in new and old houses and on their types and efficiencies.

(*c*) On the availability of smokeless solid fuels.

(*d*) On the choice of householders between different fuels.

(*e*) On the amount of useful heat demanded by the average householder.

(*f*) On the energy of the Government and of the fuel industries and on the active interest and co-operation of the public.

5. We suggest that the process will be practically complete when an additional twenty million tons of smokeless solid fuel are consumed annually with a working efficiency of not less than 40 per cent. for domestic heating. By that time there will undoubtedly be a large increase in the amount of gas and electricity consumed and in the number of appliances burning bituminous coal with much increased efficiency and reduction of smoke.

6. The date of completion of the programme is likely to depend mainly on the rate at which additional supplies of smokeless solid fuel are made available. If it averages one million tons each year, then the programme will be completed in 20 years. If the increase averages only 650,000 tons each year, then it will take 30 years to complete the programme.

7. **We recommend that it should be the target of a national domestic fuel policy to secure that the 50 million tons of bituminous coal now burnt with a working efficiency of 20 per cent. should be replaced in 20 years by smokeless solid fuel, or by bituminous coal burnt smokelessly, or by gas, or by electricity, with an average coal economy efficiency of not less than 40 per cent.**

This would render possible the following results:—

The virtual abolition of domestic smoke.

Less labour and dirt in the house.

And either:—

(a) Doubling the useful heat in the smaller houses at little or no greater cost to the householder and no increase in the consumption of coal; or

(b) An increase of 50 per cent. in the useful heat in the smaller houses with a substantial reduction in cost to the householder and a saving to the nation of perhaps ten million tons of coal per annum.

Chapter XV

SUMMARY OF OBJECTIVES AND RECOMMENDATIONS

(*References in brackets are to Chapters and Sections in the Report*).

1. Objectives. (II.)

(a) To ensure good standards of heating in the house.

By this we mean the provision of fuels and appliances of qualities and at prices that will enable householders in general to afford conditions of full health and comfort for all members of the household, with the minimum of dirt and labour.

We accept as desirable the standards of space and water heating laid down in the Egerton Report.

(b) Low Costs and more convenience for the Householder.

To ensure that the heating installation and the fuels available shall be such as to enable the householder to secure the full Egerton standards, or at his choice a lower standard, at the lowest cost (including both capital and running costs).

(c) National Fuel Economy

To ensure that all fuels shall be used in the most efficient and economical manner with due regard to the need for conserving the national reserves of coal.

(d) Smoke Abatement

To abolish the pollution of the atmosphere from domestic sources by soot and tar, and to reduce to the lowest practicable limit the emission of sulphurous gases.

2. Heating Appliances for a Single Small Dwelling. (III.17)

(a) The Government should encourage the production of improved heating appliances for all fuels and for all domestic purposes.

It is particularly important to develop multi-fuel appliances to burn efficiently and as smokelessly as possible both bituminous coal and smokeless solid fuels.

(b) Minimum standards should be established as soon as possible for all leading types of appliances.

(c) The manufacture and sale of new appliances falling below approved standards should be prohibited as soon as practicable.

(d) The Government should take steps to ensure that the codes of practice on heating and ventilation installations should be effectively adopted in all new houses.

(e) The Government should be responsible for ensuring the proper type testing of appliances, and the organisation should be rapidly developed to enable them to perform this work without causing delay to manufacturers in introducing new appliances.

(f) The Government should take steps to secure the mass production of standardised domestic fuel appliances.

(g) The Government should make every effort to secure the installation in all new houses of approved appliances for winter space and water heating to burn smokeless solid fuels or to burn bituminous coal with a minimum of smoke.

(h) In subsidised houses the Government should make the use of approved solid fuel appliances a condition of subsidy, and should consider the advisability of a free issue of such appliances as part of the subsidy.

(j) Old-fashioned coal grates in existing houses should be replaced wherever practicable by new approved appliances. Subsidies should be granted by the Government to encourage widespread and rapid action on these lines. (XIII. 4)

3. Central and District Heating. (IV.7)

(a) Central heating plants should be accepted as the main means of heating blocks of flats or single large houses.

(b) The Government should endeavour to ensure that the available supplies of smokeless solid fuel should be burnt in individual houses, and that suitable types of central heating and district heating plants should burn bituminous coal.

(c) Suitable classes should be made available all over the country for training stokers.

4. Division of the Load between Different Fuels. (V.11)

(a) The main winter space and water heating load should be taken by solid fuel.

(b) Intermittent space and water heating for short periods should be taken by gas and electricity.

(c) Subject to (a) and (b) the domestic heating field should be left for free competition between the various fuels.

(d) It should be the policy of the Government to replace bituminous coal in all single house appliances by smokeless solid fuel as rapidly as adequate supplies can be provided at a reasonable price.

(e) Even in thinly populated rural areas, the ultimate objective should be to lay on electricity to every house, so long as this does not throw excessive burdens on the consumers of electricity elsewhere.

5. Solid Fuels. (VI.15)

The Government should—

(a) Encourage the largest practicable increase in the production of smokeless solid fuels suitable for domestic purposes.

(b) In particular take active steps to secure a very large development in the supply of anthracite and dry steam coal.

(c) Encourage improved and uniform quality and grading of smokeless solid fuels for domestic purposes.

(d) Encourage the formation of an effective sales and maintenance organisation for the solid fuel industries.

(e) Give serious attention to the reduction in the cost of all coal, and particularly of anthracite.

6. Gas and Electricity. (VII.8)

(a) Free competition should continue between gas and electricity for domestic heating, subject to the condition that the prices charged should be appropriately related to costs.

(b) The outcome of the competition between gas and electricity and the influence exercised by the systems of tariffs upon the progress of the two industries should be kept under constant examination.

(c) The Ministry of Fuel and Power should make arrangements for the collection of detailed statistics on this question.

7. Design of the House. (IX.8)

(a) All houses should be so built and equipped as to make it possible to provide the standards of heating which we have recommended at the lowest possible cost.

(b) The insulation of the walls and roof of the house and of the hot water system should be in accordance with the recommendations of the Egerton Report and of British Codes of Practice when adopted.

(c) A flue suitable for a solid fuel appliance should be provided in the living room, and the means for heating one bedroom by gas or electricity should further be provided.

(d) The building owner should supply an efficient solid fuel appliance or appliances.

(e) Electric points should be provided in the main rooms; gas connections in the rooms with flues and in other rooms where gas is likely to be used.

(f) A store to contain between one and two tons of solid fuel should be provided for each dwelling.

8. Research. (XI.4)

(a) Expansion of research and development is urgently necessary in the next few years if our programme for adequate, efficient, economical and smokeless domestic heating is to be successfully carried out.

(b) Large scale user trials should be undertaken by the Government.

9. Information, Education and Service. (XII.4)

(a) The Government should establish information centres in London and in principal cities in the regions, with skilled staffs of heating engineers, architects and scientists, and with showrooms, where examples of all the best types of appliances could be seen.

(b) The work of the Fuel Efficiency Directorate of the Ministry of Fuel and Power in educating housewives should be continued and developed.

10. Smoke Abatement. (XIII.11)

The necessary legislation should be passed to enable smokeless zones to be established, and a few such zones should be declared, mainly for experimental purposes.

11. A Long-Term Programme. (XIV.7)

It should be the target of a national domestic fuel policy to secure that the 50 million tons of bituminous coal now burnt with a working efficiency of 20 per cent. should be replaced in 20 years by smokeless solid fuel, or by bituminous coal burnt smokelessly, or by gas, or by electricity, with an average coal economy efficiency of not less than 40 per cent.

This would render possible the following results:—

The virtual abolition of domestic smoke.
Less labour and dirt in the house.

And either:—

(a) Doubling the useful heat in the smaller houses at little or no greater cost to the householder and no increase in the consumption of coal; or

(b) An increase of 50 per cent. in the useful heat in the smaller houses with a substantial reduction in cost to the householder and a saving to the nation of perhaps ten million tons of coal per annum. ...

E. D. SIMON, Chairman.
GEOFFREY CROWTHER,
J. H. M. GREENLY,
ERNEST S. GRUMELL,
H. HARTLEY,
C. N. HINSHELWOOD,
JOHN JEWKES,
JAMES MACKINTOSH,
RIDLEY,*
ROBERT ROBINSON,
GEOFFREY SUMMERS.

R. E. L. CLEAVER,
Secretary.
17th January, 1946.

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* Subject to reservations on page 36.

MEMORANDUM OF RESERVATIONS

By Viscount Ridley

I agree with my colleagues on the Council on the recommendations in the Report with the following reservations:—

1. While agreeing with the general policy for minimum standards of solid fuel appliances in Chapter III, Section 11, I think that the recommendation goes too far in respect of open grates for burning bituminous coal. While it may be proper to prohibit the sale of inefficient appliances for smokeless fuels, we must recognise the fact that much of the domestic heat in the near future must come from bituminous coal, and also that many people in this country enjoy an open coal grate, which makes up for its thermal inefficiency by contributing a sense of comfort and cheerfulness. I would not agree in recommending that the sale of such appliances should be forbidden. I would suggest that every effort should be made to make such appliances as efficient and smokeless as possible, while retaining their present amenities. For example, separate standards in this respect might be adopted, and a high purchase tax might be imposed on those which do not reach these standards.

2. Further, in Chapter III, Section 14, on manufacture, I think that it would be a mistake to overdo standardisation of manufacture, which is of course not the same thing as the imposition of minimum standards of performance. I believe that large scale manufacture on Government order would tend to reduce unduly the number of types and to restrict progress of design. The evidence we have had shows that progress is still very necessary, and it seems clear that the number of new houses contemplated during the next few years will call for such a number of fuel appliances as to allow full scope for the manufacture of all appliances with the requisite standard of performance. In most forms of manufacture there is a minimum rate of production up to which unit costs are progressively reduced, and above which there is not the proportionate reduction of cost per unit with increased output, and it seems to me that this rate of production should easily be reached for several types of fuel appliances if the building of houses goes at the rate now contemplated.

3. Chapter V, Section 11 (*e*). I do not agree to the qualification attached to the installation of electricity in rural areas. The need for electricity in scattered rural houses is so great that it should be much more readily and cheaply made available. The people who live in town houses have for long had an unfair advantage in this respect, and it seems to me time that the cost of bringing electricity to all houses in the country and in towns alike should be spread over the community.

4. Chapter XIII, Section 11. In view of what we know of the available supplies of smokeless fuels and modern efficient appliances, I do not think it practicable that legislation should now be passed to enforce smokeless zones. One town such as St. Louis might be able to do so, where the means of obtaining plenty of smokeless fuel, in spite of the distances involved, were adequate, and in conditions where apparently people did not desire open coal fires.

The problem in this country is far more complicated and, while I agree on the desirability of abolishing smoke, I think that any legislation should at least be delayed until there is more widespread knowledge of modern methods of burning fuel, until public opinion has been further educated on the subject, and until there are adequate supplies of smokeless fuel and suitable appliances.

RIDLEY.

APPENDIX I

ESSENTIAL STATISTICS OF DOMESTIC CONSUMPTION OF FUELS

Throughout this Appendix the statistics refer to the year 1938 and apply to Great Britain. The statistics of consumption of coal and coke in domestic premises are estimates based on statistical returns which became available for the first time during the war years. Those for gas and electricity are estimates based on returns from undertakings which do not cover the whole of the two industries.

TABLE I

DOMESTIC CONSUMPTION (QUANTITIES OF FUEL USED)

Coal	Million tons
As bituminous coal consumed raw	49·2 (*a*) (*b*)
As anthracite consumed raw	1·2 (*a*) (*b*)
As used in the manufacture of gas and coke for domestic consumption (*c*)	7·4
As used in the generation of electricity for domestic consumption (*d*)...	4·1
	61·9
Oil	
Kerosene	0·4
Gas, diesel and fuel oil	negligible.

(*a*) Including disposals to all non-industrial consumers taking less than 100 tons of coal and/or coke per annum, some of whom are partly or entirely non-residential.

(*b*) Including miners' coal, totalling 4·6 million tons.

(*c*) Assuming overall production and distribution efficiency 73 per cent. : See Table V.

(*d*) Assuming production and distribution efficiency 18 per cent. : See Table V.

TABLE II

PROPORTION OF OUTPUT OF COAL, GAS AND ELECTRICITY INDUSTRIES CONSUMED IN DOMESTIC PREMISES

	Total Output	Delivered to domestic premises	Percentage of output of industry
Coal—Million tons	181 (*a*)	50·4 (*b*)	28
Coke—Million tons	21 (*a*)	2·5	12
Gas (*c*)—Million therms ...	1,530	925	60
Electricity (*d*)—Million units	20,793	5,360	26

(*a*) Excludes exports and foreign bunker shipments.

(*b*) A further 11·5 million tons is estimated to have been used in gas and electricity works for the production of fuels for use in domestic premises.

(*c*) Gas sold by statutory and other undertakings but excluding gas sold by coke-ovens apart from the quantity resold by gas undertakings.

(*d*) Electricity sold by authorised undertakings.

TABLE III

DOMESTIC CONSUMPTION (HEAT OBTAINED IN HOUSEHOLD)

	Millions of tons of coal used	Coal Economy Efficiency (for all household uses)	Useful heat equivalent to millions of tons	Percentages of heat in household
As raw bituminous coal and anthracite.	50·4	20·0	10·0	80
As used in the manufacture of gas and coke for domestic consumption.	7·4	25·5 (*a*)	1·9	Gas 10 Coke 6
As used in the generation of electricity for domestic consumption.	4·1	14·5 (*b*)	0·6	4
	61·9	—	12·5	100

(*a*) Assuming production efficiency 73 per cent. and average working efficiency 35 per cent.

(*b*) Assuming production efficiency 18 per cent. and average working efficiency 80 per cent.

TABLE IVA

DIVISION OF DOMESTIC HEAT SERVICES AMONG THE DIFFERENT FUELS

We are indebted to the Gas Advisory Committee for the following estimate of the proportions in which the useful heat in the house is provided by the various heating agents:

Agent	Cooking	Water heating	Room heating
Coal	20–25 per cent.	60 per cent.	75–80 per cent.
Coke and Anthracite...	—	20 per cent.	15 per cent.
Gas	70 per cent.	15 per cent.	5 per cent.
Electricity	10–5 per cent.	5 per cent.	Up to 5 per cent.

For comparison we also summarise the relevant information obtained by the Wartime Social Survey:—

TABLE IVB

DIVISION OF DOMESTIC HEAT SERVICES AMONG THE DIFFERENT FUELS

[Based on information obtained in the Heating of Dwellings Inquiry, carried out in February and March, 1942, by the Wartime Social Survey. The inquiry consisted of a questionnaire addressed to a carefully selected sample of 5,260 households and its results are fully described in Appendix I of Egerton Report.]

	ROOM HEATING Percentages of rooms heated by each fuel.			WATER HEATING(c) Percentages of households using different methods of heating water for baths and washing clothes, grouped according to fuels required.		COOKING (e) Percentages of households using each fuel.	
	Kitchen (a)	Bedroom when heated (b)		Baths	Clothes	Winter	Summer
		Over 8 hours	Under 8 hours				
Coal and Solid Fuel	95	89	41	46	42	52	34
Gas ...		2	17	17	31	72	76
Electricity	5	5	34	2	4	9	10
Others ...				35 (d)	23 (d)	3	3
Sample ...	100						

(a) Egerton Report, Appendix I, Section A.1.4.5, which also states that 96 per cent. of kitchen-sitting-rooms and 96 per cent. of sitting-rooms are heated by coal.

(b) *ibid*, Table 30. Section A.1.4.5, referred to in (a) above, also gives an overall figure of 48 per cent. of bedrooms as being heated by coal.

(c) *ibid*, Table 53.

(d) including 30 per cent. and 16 per cent. respectively using pans, kettles, etc., on the fire, stove, range or cooker.

(e) *ibid*, Table 13 and Section A.1.3.2. These two columns are based on answers to a question: "What fuel do you use for cooking in winter and summer?" The Survey commented that many housewives use more than one of the fuels, particularly in winter, as will be seen from the results of this question. This results in the totals given in these columns adding up to more than 100 per cent.

TABLE V

PRODUCTION EFFICIENCIES

Therms delivered to appliance per 100 therms of coal carbonised or used at the power station.

	Gas	Coke	Tar, etc.	Total Production Efficiency
Gas Works	25	40·5	7·5	73
Electricity Generation and Distribution.	—	—	—	18

In Table I for the purpose of arriving at the coal carbonised to produce given quantities of coke and gas the convention has been adopted of assuming that both gas and coke are produced with an efficiency of 73 per cent. in the carbonising process.

An alternative convention is to assume that coke production involves 100 per cent. and gas production 48 per cent. efficiency in the carbonising process. Thus the calorific values of the coke and tar add up together to 48 therms out of 100 therms of coal carbonised, leaving a residual of 52 therms from which 25 therms of gas are regarded as emanating, *i.e.*, production efficiency of 48 per cent.

For a more detailed statement of these alternatives see Section 6.1.1. of Egerton Report.

For more detailed calculations to arrive at production efficiencies see Table 6 (1) of Egerton Report and Annexes A and B to Chapter 6 of that Report.

TABLE VI

COAL ECONOMY EFFICIENCIES (OBTAINED IN CONTINUOUS SPACE-HEATING APPLIANCES)

	1. Production Efficiency	2. Test-bench Efficiency	3. Appliance Efficiency	4. Coal Economy Efficiency
A1. *Coal* in open grate ...	100	25	20	20
A2. ,, ,, closeable fire (open).	100	50	40	40
A3. ,, ,, closeable fire (closed).	100	60	45	45
B1. *Coke* in open coke grate	73	30	25	18
B2. ,, ,, closed stove ...	73	65	55	40
C1. *Gas* fire	73	45	40	29
C2. ,, ,, with convection	73	60	55	40
D1. *Electric* fire	18	100	100	18

The above Table is a simplification of Table 6 (2*a*) of the Egerton Report.

Notes :—

Column 1.—For purposes of comparison, production efficiencies of gas and coke are cited as 73 per cent. (see Table V). The Egerton Table also contains a comparison assuming production efficiencies of 100 per cent. and 48 per cent. for coke and gas respectively (see Note on our Table V above), which results in a proportionately higher coal economy efficiency for coke and a lower one for gas in Column 4.

Columns 2 and 3.—The approximate mean of the ranges of test-bench efficiencies and appliance efficiencies cited in the Egerton Report has been taken in every case. The Egerton Report's use of the latter term is referred to under our definition of working efficiency in Appendix V.

The efficiencies in our Table against A1, B1, C1 and D1 represent those obtained with re-war appliances. Those against A2 and 3, B2 and C2 with modern appliances.

TABLE VII

HEAT AND POWER EQUIVALENTS

The following Table gives the heat and power equivalents for the principal fuels dealt with in the Report.

(1)

Coal Pounds	*B.Th.U.*	*Gas Therms*	*Electricity Kwh*
1	13,400	·13	4
$7\frac{1}{2}$	100,000	**1**	30
$\frac{1}{4}$	3,400	·03	**1**

(2)

Coal Tons	*B.Th.U. Millions*	*Gas Therms*	*Electricity Kwh*
1	30	300	9,000
3,300	100,000	**1 million**	30 million
110	330	33,000	**1 million**

Notes :—

(1) For simplicity 1 ton of coal is assumed to be equivalent to 300 therms, which is correct for coal of a calorific value of 13,400 B.Th.U. per lb. The calorific values of different classes of coal in fact may vary by nearly 20 per cent. from this upwards or by more downwards. Thus :—

Domestic coal	1 lb. = 13,000 B.Th.U.
Anthracite	1 lb. = 15,000 B.Th.U.
Gas coal	1 lb. = 13,400 B.Th.U.
Coal used at electricity generating stations ...	1 lb. = 11,000 B.Th.U.

The above variations in calorific value have been taken account of in the preparation of Table I.

(2) For simplicity 1 unit of electricity is assumed to be equivalent to 3,400 B.Th.U. giving 30 kwh to 1 therm. The equivalent is in fact 1 unit of electricity = 3,413 B.Th.U. giving 29·3 kwh to 1 therm.

(3) Domestic coke ... 1 lb. = 12,200 B.Th.U.

(4) One lb. of kerosene ... = 19,900 B.Th.U.
One lb. of fuel oil ... = 19,500 B.Th.U.

APPENDIX II

SMOKE ABATEMENT

By Professor James Mackintosh, M.D., F.R.C.P.

1. *Introduction*

The nuisance of coal smoke has been a cause of complaint in England for centuries, and legislation against it dates back to the reign of Edward I. In 1661 Evelyn wrote in his Diary of " that hellish and dismal cloud of sea-coal which is perpetually over this august and opulent city of London ". With the coming of the industrial revolution the problem became much more acute, because of the enormously increased consumption of coal and the ill-planned concentration of factories and dwelling houses in our great cities. Unfortunately the prevailing tendency of the age was laissez-faire, and, in the words of Sir John Simon*:—

> " See with what apparent indifference our nineteenth century England acquiesces in a daily increasing sacrifice of daylight to dirt. There are immense masses of our population—the inhabitants, for instance, of London and of many chief manufacturing towns—who endure without revolt or struggle the extremities of general *Smoke Nuisance;* not only condoning

* " English Sanitary Institutions " (1890) by Sir John Simon, K.C.B., Chief Medical Officer, Local Government Board.

the fact that the nuisance is of painful injury to an appreciable number of persons, and in certain states of the weather kills many of them; but further accepting, as if in obedience to some natural law, that their common life shall in great part be excluded from the pure light of day by an ignoble pall of unconsumed soot; and hardly murmuring, in their self-imposed eclipse, that their persons and clothing and domestic furniture are under the incessant grime of a nuisance which is essentially removable."

This indifference persists. Parliament has appointed committee after committee to inquire into the smoke nuisance, and has with great consistency paid no attention to their reports, except to pigeon-hole them. In recent years, however, there has been an increasing public awareness of the value of sunlight and fresh air, and many scientific investigations have served to lay stress on the harm done by smoke and at the same time have shown that the nuisance can be abated by scientific methods, without injury to industry. In addition, modern methods of fuel production offer great prospects for the reduction of smoke: the gas industry and the electricity industry have taken over a large proportion of the domestic cooking load, and are replacing coal for a certain amount of water and space heating. The use of the old-fashioned kitchen range which burned large quantities of coal in the smokiest possible way has given place, partly to gas and electricity, and partly to efficient solid fuel cookers which are practically smokeless. As the domestic fire is the chief sinner in smoke production, progress in this direction is of the utmost importance.

2. *Comparative Studies*

As a result of his experience as Chairman of the Departmental Committee on Smoke Abatement, which reported in 1921, Lord Newton wrote over twenty years ago:—

"The deplorable atmospheric conditions under which a large proportion of the British race lives can only be appreciated fully by those who have had an opportunity of comparing them with those prevailing in other countries. It is no exaggeration to say that many millions of inhabitants of the north of England have never seen real sunlight in their places of residence except in the event of a bank holiday or of a coal strike, and most of them have become so inured to this deprivation that they are profoundly sceptical as to any possible remedy. There are, too, a large number who entertain the conviction, naturally encouraged by certain manufacturers, that dirt and wealth are synonymous, and that consequently any attempt to abate smoke must be disastrous to industry. It is a pity that persons holding these views should not have the opportunity of seeing what can be effected in other countries."

It is distressing to an Englishman to compare London with New York or Stockholm, or industrial cities like Chicago and St. Louis with Manchester and Leeds. Yet there is no essential reason why the English industrial towns should be more smoke-laden and dirty than their American counterparts. Cardiff, for example, has a relatively clear atmosphere, due no doubt partly to the extensive use of dry steam coal.

St. Louis is an industrial city with a population of 850,000. In 1940 it was one of the most notoriously smoky cities in the United States. For years the town had spent large sums of money on propaganda and instruction by radio and press, but the results were negligible. As the fault lay with "small, numerous, and widespread fires", it was not possible to control nearly a million people. The first step in progress was to introduce a "washing clause", which reduced the ash content of coal to not more than 12 per cent. and the sulphur compounds to 3 per cent. In 1940 it was decided

to deal with the situation in a much more radical way, and the new regulations provided that:—

(1) bituminous coal of more than 23 per cent. volatile matter could be used only in appliances fitted with automatic stokers.

(2) all fuel dealers must be registered, with provision for an annual renewal of their permits.

(3) all new appliances installed and all alterations to existing appliances must be approved by the Smoke Commissioner.

(4) the city authorities should be given power, in the event of emergency, to purchase and arrange for the distribution of stocks of suitable fuel.

The regulations have worked satisfactorily under both Democratic and Republican authorities, and the right of the city to make and enforce them was upheld by a decision of the Supreme Court of Missouri. The production of processed fuels has increased rapidly, and there has been a wide-scale conversion of industrial plants to automatic installations. The scheme has been successful in making St. Louis a clean city and it has earned a large measure of support from the inhabitants.

In Chicago the smoke problem is difficult to solve, partly because the city is a great railway centre, and partly because it lies close to the Illinois and the Indiana coalfields and consumes more smoky soft coal than any other city in the United States. The authorities carry out an immense educational programme, issuing free of charge illustrated booklets to engineers and house caretakers, to advise on the best methods of stoking. Before any fuel installation is made, the plans must be submitted to the Smoke Prevention Department, and only approved designs are accepted. All new or reconstructed furnaces must be made to operate smokelessly.

Smoke abatement has been tackled more radically in New York. In the city itself no coal-burning locomotives are permitted, the two main lines being underground and completely electrified, and in the surrounding areas only low-volatile coal is used in yards and engine sheds. Great progress has also been made towards the elimination of smoke from ships and riverside installations. The fuel consumed for all purposes in New York is three quarters coal and one quarter oil. Of the former 53 per cent. enters the city as anthracite, 46 per cent. as bituminous coal and 1 per cent. as coke. A considerable additional amount of coke is produced from coke ovens, etc., within the city. Practically the whole of the bituminous coal is used in the central electricity works and in gas making, and in these installations smoke emission is carefully controlled. In private installations the use of smokeless fuel is practically universal.

In general, the American authorities rely for their success in smoke prevention on four main principles, all of which are applicable in this country:—

(1) to encourage the use of smokeless fuels. It is worth noting that low-volatile coal used in St. Louis and Chicago is transported from the West Virginia coalfield—a distance of over 500 miles.

(2) to insist that all new or reconstructed heating apparatus is submitted for approval to a Smoke Prevention Department.

(3) to carry out a continuous campaign by press and radio, and to issue free, well-illustrated booklets of instruction to all concerned with smoke production.

(4) to encourage district heating. This is well expressed in the report of one of the experts in New York: "Both sulphur and soot," he says, "will keep coming from thousands of our small fires so long as these exist. The best thing is to discourage them, to encourage further use of

electricity, gas and public service steam. This concentrates as much coal burning as possible in a few large plants, where inspection is easy and large scale devices for fume and smoke reduction can be used."

3. *Damage caused by smoke in England*

It is generally admitted that more than half the smoke that pollutes the atmosphere of our towns comes from the domestic fire. The open fire in the home makes twice as much smoke per ton of coal as the average industrial works. Considerable progress has been made in recent years in the survey of atmospheric pollution and in determining the real nature of the problem. The following facts are taken from the authoritative appendix on smoke abatement in the Egerton Report*:—

When coal is burnt in the ordinary open fire, the material that escapes into the air from the chimney is made up as follows, as a percentage of the weight of the coal:

2.7 per cent. as soot or semi-liquid tarry globules.
0.3 per cent. as ash.
2.4 per cent. as sulphur dioxide.

Total 5.4 per cent.

The damage done by domestic smoke is estimated at no less than £20 millions per annum†. Although many aspects of the damage are impossible to assess in terms of money, we consider this to be a conservative estimate. Indeed, we believe the damage done to the health and happiness of the people of our great cities is much more important than the direct injury to materials and buildings or the extra cost of cleaning and washing. City dwellers are poisoned by breathing air charged with soot and tar and sulphur. Even more serious is the loss, due to smoke, of visible daylight and of the ultra-violet rays which together do so much to make life pleasant and exhilarating. Life in a city slum is dirty, drab, dreary and depressing. The fact that such losses do not lend themselves to objective measurement does not mean that they are non-existent. Full health and vigour are impossible for unfortunate persons condemned to live permanently in such surroundings.

4. *Recent Investigations*

During the past twenty-five years a large amount of information has been collected about the atmospheric pollution at a few fixed points in each of a number of large towns, but there has been no accurate knowledge of the "life history" of pollution or of how the air of a town is cleaned by natural means. Another important question, hitherto unanswered, is how far pollution can travel from its source, and how much and how rapidly it spreads within and around a town under various meteorological conditions. Many of these questions have been studied in a scientific survey carried out in Leicester by the Department of Scientific and Industrial Research. The Report‡ shows that the highest concentration of smoke, and of sulphur dioxide, was nearly always found within half a mile of the centre of Leicester, no matter what the direction or velocity of the wind. In winter there was nearly ½ milligram each of smoke and sulphur dioxide in a cubic metre of air; and in summer the average concentration of each was 1/5 milli-

* Egerton Report, Appendix 4. Table A 4 (1).
† *ibid*, Section A.4.5.3.
‡ "Atmospheric Pollution in Leicester," H.M. Stationery Office, 1945. Price 3s. 0d. (3s. 3d. including postage).

gram per cubic metre. Both smoke and sulphur dioxide varied greatly with changes of weather, their concentration sometimes reaching six times the average.

In contrast with these results smoke and sulphur dioxide differ in their distribution within Leicester, and also in their weekly cycle. Both differences are bound up with the fact that domestic fires produce a lot of smoke in proportion to the weight of coal burned. For instance, an average of more than twice as much smoke is produced per ton of coal burned in the suburbs compared with the centre of the city.

In spite of the broad agricultural belt surrounding Leicester, the pollution reaching it from the nearest industrial districts is considerable, varying between 10 and 40 per cent. of the total pollution at the centre of the city.

An instrument for measuring the amount of ultra-violet radiation received each day from the sun and the sky was specially designed for the Leicester survey. It was found, on an average, that about 60 per cent. of the incoming radiation was lost because of clouds, and in winter a third of the remainder was absorbed by the smoke over the centre of the city. On an average winter day in Leicester visibility is limited by smoke alone to less than 1,300 yards, irrespective of the effect of fog or rain droplets. On the smokiest days this distance is reduced to 200 yards.

It has often been suggested that " smokeless zones " should be created in the centre of cities, but the Report shows that the results will not be spectacular. A central park, for example, is a smokeless zone, but experiments made in connection with the survey showed that, in London, Hyde Park was only a quarter less smoky than the surrounding district. As the Report says: " The introduction of small smokeless zones is unlikely to bring about a great increase in the popular demand for purer air, unless the improvements are measured accurately and the results made public. The same difficulty will probably beset any other partial measures, unless they provide a sharp contrast in smokiness between two contiguous areas. Hence it is imperative that all special measures against pollution should be accompanied by systematic observations, for the information both of the authorities and the general public."

5. *Urgent need for Reform*

It is true that the increased use of gas and electricity, and the installation of better solid fuel appliances for cooking, water heating, and space heating in houses have made a modest contribution to the reduction of domestic smoke. But little has been done to deal with the problem on an adequate scale. It is a tragedy that successive governments have ignored the recommendations of the Newton Committee. The householder is not interested in smoke abatement; he chooses his methods of heating without any regard to the wider issues, and it can hardly be expected that he will do otherwise in the future. Smoke abatement, like any other measure of public health, must come, not from the free choice of individuals, but from concerted action by the State through the agency of local authorities. Unless the Government takes responsibility for the removal of the smoke nuisance, the present obnoxious conditions will continue indefinitely.

Educational methods, if properly carried out, are good up to a point; they help to create a strong public opinion. But in matters of this kind public opinion must find expression in legislative action in the interests of the community as a whole. The next move lies with the Government.

APPENDIX III

COMFORT REQUIREMENTS IN THE HOME

By Professor James Mackintosh, M.D., F.R.C.P.

Guide to Sections :

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A. Space Heating and Ventilation

I. Standards

1. *Limitation to the Ordinary Dwelling*

The objective in providing heating and ventilation is to contribute towards human health and comfort, but in order to understand the necessary conditions for physical comfort we must first limit the field of study. For our present purpose we are concerned with the ordinary British family at home—with the needs of father, mother and children, in a reasonably well-constructed dwelling which is not overcrowded. Public buildings, factories, trains and buses, and other places where people congregate demand highly specialised apparatus for controlling the temperature and the movement of the air; but in the home the problem is much simpler, because the conditions necessary for comfort can be readily adjusted by the occupants, if the primary need for warmth in cold weather is satisfied. There is no case for making special provision against extreme heat by air-cooling devices. The British climate is temperate and on the whole invigorating, but inclined to dampness. Cold and wet are the chief enemies of comfort in this country.

2. *Comfort in the Home*

It is hard to define the term "physical comfort" even within the restricted sphere of warmth and ventilation. There is an extraordinary confusion of mind in this country between ventilation and cold, although (as Florence Nightingale pointed out* nearly a century ago) "to have the air within a room as pure as the air without, it is not necessary, as often appears to be thought, to make it as cold." For a person at rest in an ordinary room "comfort" may be described in general terms as "that sensation of physical well-being related to an environment in which bodily heat is dissipated at approximately the same rate to the surrounding atmosphere as it is produced within the body." The mechanism of heat regulation within the body is complex, but a fairly accurate picture can be drawn in a few simple outlines. The body at rest produces heat by the combustion of food and normally maintains a temperature between 98° and 99°F., considerably higher, that is, than the usual temperature of the surrounding atmosphere.

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* "Notes on Nursing," by Florence Nightingale.

The object of warming a house in cold weather is not to supply heat directly to the human body, but to temper its environment in such a way as to prevent excessive or irregular or too rapid loss of heat. The heat-regulating mechanism of the body has fairly wide powers of adaptation to changing environmental conditions as well as to its own needs. This adaptation helps to maintain what has been termed a *zone of comfort** within which even in a person at rest there is a physiological balance between heat production and heat loss.

3. *Effects of Overheating*

Above this zone—that is, when the environment becomes too hot—the body tries to restore the balance by increasing heat loss. This is achieved up to a point by the insensible evaporation of moisture from the skin, which cools the body surface, and by the cooling effect of increased respiration. As the temperature rises still further, active excretion of sweat takes place. When heat and especially humidity rise to such a point that sweat can no longer evaporate, the subject passes beyond the " zone of evaporative regulation " and suffers increasing discomfort to the point of prostration. The discomfort thus produced is not due to any chemical change in the composition of the air, nor even in the main to breathing air of high temperature and humidity; it is a reaction of the body surface as a whole. Experiments conducted in Britain and America all confirm the conclusion that overheating and humidity, not chemical vitiation of the atmosphere, are the main causes of discomfort, but the effect is greatly enhanced by decreasing air movement. In other words, " the problems underlying the physiology of ventilation are physical rather than chemical; cutaneous rather than respiratory ".†

One other factor in the production of heat discomfort must be referred to at this point. In overcrowded rooms " the rancid vapours from human bodies "‡ can be produced at any temperature, but they are more liable to add to discomfort when the temperature is high.

4. *Effects of Underheating*

When we come to the lower end of the zone of comfort, and environmental conditions remove too rapidly the heat produced by the body, the physiological reactions are entirely different. The body adapts itself in some degree by contracting the blood-vessels supplying the skin, thus decreasing heat loss; and at a still lower stage the muscular movements of " shivering " tend to produce some heat. This adaptation is only partially effective, and a sense of coldness supervenes with its accompanying discomfort. There is no convincing evidence that, in addition to discomfort, a uniform degree of coldness or rapid heat loss from the body directly produces actual illness. But there is good reason to believe that irregular cooling of the body, that is, chilling of a part of the body, is attended by some risk. This is especially so when the change from a heated atmosphere, in which a person has been sweating freely, to " one-sided " cold takes place suddenly. Examples of this occur when a person, immediately after taking vigorous exercise, sits down in a draught, or when a person remains for a long period with his feet cold and wet. " Draught " has been defined as " the unpleasant sensations that arise from a one-sided cooling of the body or some part of it. This is frequently caused by a corresponding motion of cold air, but also in other ways, as by increased one-sided radiation ".

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* C-E.A. Winslow, Dr. P.H. " Housing for Health."

† Report of the New York State Commission on Ventilation, pp. 8–12, etc.

‡ Rev. Stephen Hales, D.D., F.R.S., 1758.

The adaptation of the body to cold is limited, and a point is reached, subject to individual variations, at which no internal heat production can combat the cold; at this point discomfort passes into the more serious effects of exposure.

5. *Medical Considerations*

As we are dealing with the conditions obtaining in an ordinary uncrowded dwelling in this country there is no need to enter into a discussion of the clinical effects of extremes of heat and cold. The ill-effects upon health and well-being of overcrowding, of slum conditions, and of gross housing defects of structure and repair are notorious, but they lie outside the scope of this report. We are concerned with the lesser degrees of faults in heating and ventilation and their possible effects upon health.

As regards systemic diseases, there are no studies offering any *scientific* proof of the part played by cold in producing disease, but many writers restate the clinical (and everyday) opinion based on a wealth of experience that low temperature may have an adverse effect on health. Few of these writings, however, take into account the complicating factors such as overcrowding, lack of sunlight and fatigue. There is much stronger evidence to indicate that unequal chilling of the body—the exposure of a part of the body to cold, especially in a person who has become overheated—lowers resistance to infection, or may give rise to a local inflammatory reaction. A draught of cold air on one part of the body may well be injurious to health, and such complaints as " stiff neck " or neuralgia are often directly attributable to sitting in a draught. There are substantial medical grounds for supporting the common belief that sudden changes of temperature, especially from heat to cold, tend to lower bodily resistance, but the consequences—translated into terms of diagnosis—depend on many factors, such as the presence and concentration of infecting organisms, or the existence of any special forms of bodily weakness, at the time of exposure. Many infections occurring in epidemic form strike their victims without respect of person or environment, the spread of the disease being limited only by the virulence of the organism and the immunity of the host. On the other hand, a varying number of persons, whether under epidemic conditions or otherwise, after infection by disease-producing organisms maintain for a time an uneasy struggle between health and sickness. It is in such persons that a lowering of resistance produced by chill or other environmental hazard may precipitate illness.

6. *Standards of Space Heating*

There is little conflict of opinion about the range of the comfort zone for winter warmth. For general purposes a fairly uniform air temperature of 65° F. has been accepted in this country for over a century, together with air change of 10 cfm. per person, as recommended by Reid in 1844. Under the usual calm air conditions of an ordinary living room in normal occupation (15-25 fpm.) an air temperature between 62° and 70° with a relative humidity between 30 and 60 per cent. represents the limits of the comfort zone. A better index of comfort is provided by the equivalent temperature* (which takes into account the combined effects of air temperature, air movement and radiation). In this country most people would feel comfortably warm within an equivalent temperature range between 62° and 66°, with a maximum of 68° and a minimum of 60°. The Americans

* The scale of *equivalent temperature* takes into account the radiation from solid surroundings and also the temperature and rate of movement of the air. It makes no allowance for atmospheric humidity, but at the temperatures normally encountered in uncrowded British homes humidity has but a small influence on our feelings of warmth, and therefore equivalent temperature is a valuable index.

prefer a somewhat higher figure (and in practice tend to go beyond the upper limit); but the Scandinavian countries differ from the British only in the fact that they achieve the desired temperature in their homes.

Bedford gives an excellent summary of the conditions desirable for health and comfort—a pleasant and invigorating atmosphere:—

(i) A room should be as cool as is compatible with comfort.

(ii) There should be adequate air movement. At room temperatures customarily maintained in winter in Great Britain the velocity should be about 30 fpm.; velocities below 20 fpm. tend to cause feelings of stuffiness.

(iii) The air movement should be variable rather than uniform or monotonous, for the body is stimulated by ceaseless changes of environment.

(iv) The relative humidity of the air should not exceed 70 per cent. and should preferably be much below that figure.

(v) The average temperature of the walls and other solid surroundings should not be appreciably lower than that of the air, and should preferably be warmer. The combination of cold walls and warm air often causes feelings of stuffiness.

(vi) The air at head level should not be distinctly warmer than that near the floor, and the heads of the occupants should not be exposed to excessive radiant heat.

(vii) The air should be free from objectionable odours.

7. *Background Warmth*

It has been suggested (Egerton Report, Section 2.1.4.) that the basic aim of space-heating is to provide "background warmth" in order to avoid excessive chilling of the structure of the house. By this means condensation of moisture on walls, furnishings, and household linen can be minimised; the housewife can go about her daily tasks in comfort; the risks of frost are greatly reduced; and any room in which full heating is required can be warmed up with the least possible difficulty and delay. In other words, if, under winter conditions, a temperature of about 50° F. can be maintained throughout the house, it is both easy and economical to "top up" the heating of any room to the desirable comfort temperature by means of an open fire or a gas or electric heater. Another reason put forward in favour of background heating—as opposed to full central heating—in this country is that the outside temperature varies so greatly from day to day even in winter. This variation is in striking contrast to many parts of U.S.A. and the European continent, where full central heating is rendered necessary because winter cold is both severe and continuous. There can be no doubt whatever that the introduction of background heating would improve enormously the comfort of the ordinary British home and enable many families to make better use of the room space. Under present conditions, owing to lack of heat, the vast majority of bedrooms are waste space, except when used for sleeping. In other civilised countries they are fully used by day, thus adding considerably to the real floor space of the house.

II. Space-heating and Family Life

1. *Space and Warmth*

It is possible to build a technically sound modern dwelling and yet fail to satisfy the biological needs of its occupants. The house should be a specialised institution designed to assist in the performance of certain functions: the nurture of children, preparing and serving food, personal hygiene, general cleanliness, sleep, and all the simple routine of healthy family life. In the past too much emphasis has been laid on structure and too little on function. Methods of construction do not reach their full value, if they

serve only to sustain load and provide stability against external forces; they must also provide heat insulation to enable the house to be kept warm in winter. Similarly, space in the home is of little value unless it can be used as living-space. In this country the principal faults of the past have been to neglect heat insulation in the construction of the house, and to limit space heating to one or two rooms. The latter arrangements confined family life in nearly all its functions to a small part of the total area of the home—the living room—and even that area, heated by an inefficient open coal fire, had only a narrow half circle of warmth. In cold weather the British home *is the smallest in the civilised world,* although its total space compares favourably with what is provided in most countries. In Northern latitudes generally every room in the house is warmed, and so every room is used by day as well as by night because of the warmth and comfort provided. The effect of warming the house as a whole is to distribute family activities, to allow privacy, to make quiet conditions possible for children who have to do homework, or for others who wish to have time and space to themselves. This distribution creates more healthy conditions for home life, better opportunity for work, rest and leisure activities, with less overcrowding and less friction within the family. Rooms which are used by day and kept warm are likely to be relatively dry and warm and to be free from accumulations of dirt and rubbish; whereas a cold room is apt to be neglected and allowed to become damp and fall into disrepair. The distribution of the family in the home is a progressive measure, both hygienically and psychologically; their concentration in one room for the greater part of their daily activities is biologically unsound and retrogressive.

When the children reach school age, their developing personality deserves special consideration. It is fitting that they should learn to live lives of their own, but it is not possible to give them scope to do so, if they must be confined to one room in the company of their parents, other adults, and adolescents; if they must constantly be present when there are visitors. For the parents too there are times when the presence of the children, especially in the evenings, interferes with quiet. The bed-sitting room satisfies the need for a " room of one's own " which every normal growing child feels; and this need increases as the children grow into adolescence. It is a natural and healthy development, yet it has not been recognised in this country as elsewhere. The reason is simple; the difficulty in keeping more than one room at a comfortable temperature. The contrast with countries in which central heating is the rule is striking. In U.S.A., for example, it is usual for the children to have their own apartment for work and play, even in small houses. In Sweden the effect of central heating is to introduce a new mode of living: the window, and not the fireplace, is the focus of the living-room, and chairs and tables are arranged accordingly. In summer the window is brilliantly decorated with flowers and in the cold season vines and other creepers are trained round the window with excellent decorative effect. It is quite common to have a fireplace and a flue in the living-room, but it is never used except to hold a jar full of autumn leaves, or to light a fire in the event of the rare emergency of a failure in the central heating.

2. *Space Heating Requirements in the Home*

In the standard house we have to consider space-heating in relation to the activities carried out in the various rooms, and for this purpose we may take first the design comprising working kitchen, living-room and dining annexe on the ground floor, and three bedrooms and a bathroom on the first floor. Under winter conditions the main source of space heating is in the living-room, with a fire or stove capable of water-heating for a circulating system, direct heating for the living-room and its annexe and indirect convection heating for at least two bedrooms. An efficient closeable stove in a

good position should be able to provide background heating up to 50° for these rooms and in addition radiant heating up to the comfort zone for the living-room itself. In cold weather additional heat would have to be provided as required for the dining annexe, preferably by means of a gas or electric fire of the fixed type. In the two bedrooms for which background heating is provided, "topping-up", as it is sometimes called, can be secured by gas or electricity. If one room is in frequent use as a bed sitting-room, a fixed gas or electric fire is a convenience, but in the other rooms movable radiators should meet all the requirements of intermittent warming. For the bathroom the best provision is the towel rail heated from the hot water circuit.

3. *Bedrooms*

In the new housing programme special consideration should be given to the use of one bedroom as a sitting-room and occasional sickroom. If electricity is the source of power, in addition to background heating, the obvious course to take is to instal a heating point in every bedroom, for use with a portable fire or radiator. With gas as the means of cooking it will be convenient to have a small flue in one bedroom and put in a gas fire. There is no case for a coal fire in a bedroom. In sickness the coal fire is dirty, labour-consuming and inefficient as a ventilator on account of the difficulty of control. In a sick-room it is essential to be able to turn the source of heat on or off quickly; to reduce or increase the warmth according to the needs of the patient. This cannot be done with a coal fire. The open fire in a bedroom is always a source of danger; wood may spark, and coals may drop out; a restless sick person may allow inflammable articles to fall into the hearth and be unable to retrieve them before they catch fire. The fire-guard is an indifferent protection even when it is conscientiously used. These are not imaginary risks; they are true records of what happens in this country. A gas fire and an electric radiator are safer than a coal fire in any situation, but especially in the sick-room.

It is sometimes alleged that there should be an open fire in a sick-room in order that infected dressings, etc., can be burnt at once, and not carried through the house. There is no substance in this argument. In the private house, as in hospital, infected articles should at once be placed in a suitable covered receptacle containing a liquid antiseptic. It is bad practice to throw infected material on an open fire without previous disinfection.

The best ventilator for a sick-room is the window. By this means it is easy to air a room thoroughly in a few moments without risk to a person who lies in bed well covered. When a bedroom is used as a bed-sitting room, the same conditions apply. The coal fire wastes time and energy; it is dirty; it cannot be turned on or off, up or down, as required; and the ventilation which it provides in a small room is often excessive to the point of discomfort. In a bed-sitting room the occupant generally requires warmth during the evening hours, and again for a short period in the morning. The gas fire and electric radiator supply these wants, and the coal fire does not.

4. *The Kitchen and the Dining Annexe*

Except in very cold weather the normal activities of the kitchen usually provide enough heat to maintain a reasonable working temperature. The living-room fire may be so arranged as to give some extra heat from a back plate to the dining annexe. When the kitchen is used as a living-room (a useful arrangement in rural cottages), the main source of heating will of course be in that room and a separate fire will be necessary for the parlour. This is not so economical as the working kitchen with the dining annexe to the living-room, and in practice the parlour tends to be occupied only on special occasions. In general, it may be suggested that the most efficient

and economical arrangement (from the point of view of space heating) is to have a living-room with a dining annexe, and a small working kitchen. There are many general reasons for separating the kitchen from the dining-room and the living-room, except perhaps in rural homes, and the design for modern heating affords additional arguments for this arrangement. The kitchen is apt to accumulate moisture and smells from cooking and the warmth provided incidentally to cooking is usually sufficient for the comfort of the housewife during her daily routine. As a rule the kitchen needs more ventilation than would make for comfort in a living-room. In summer it is often too hot when cooking is being done and the humidity may be excessive.

5. *An alternative system*

The alternative system of space heating is the full central heating provided in modern American and continental houses. This has the advantage of warming the whole house, including halls and passages, making the living-room fire a luxury and auxiliary heating unnecessary except for occasional use in summer.

III. Space-heating and Household Activities

1. *The Housewife*

The kitchen is sometimes called "the hub of the house." This is in many instances a true description, but it should be applicable only if the house is regarded as a workshop. But ought the home of the future to be looked upon as a workshop? Ought the housewife to be constantly in her kitchen, even at meal times? The design of the home of the future and the location and type of its heating appliances depend on the answer to this question. It is, of course, very convenient, in the absence of domestic help, to have meals in the kitchen; many well-to-do housewives have enjoyed this experience during the war and have found it labour-saving and rather jolly. Some of them are inclined to argue that the kitchen is therefore a suitable place for meals in houses built for working people. This is a fallacy, because it ignores the totally different conditions under which working people and the comparatively well-to-do live.

The housewife should be able to get away from her workshop during meals—from the sights and smells of cooking, and the pile of unwashed dishes on the draining board. Kitchen meals, however convenient they may be, are an inducement to slack service of meals in discomfort and untidiness. The family meal should be a period of orderliness, quiet, and relaxation. When there are young children in the family it is a valuable opportunity for teaching good habits and good manners. Housewives should learn that, if they are to let good digestion wait on appetite and health on both, the family meals should be properly served, and eaten in a comely way.

The hub of the home of tomorrow should be the living-room, the place where family life is carried on. The working kitchen should be the servant of the living-room, not its master. In the living-room the housewife should be able to enjoy rest after meals, and some leisure in the evenings, even if by leisure one means a change from standing to sitting at work.

2. *The Young Child*

The young infant needs more warmth than the older child, but this is normally provided by the cot and the perambulator. The only time when special warmth is necessary is when the baby is being changed or bathed, and the radiant heat of a gas or electric fire, in addition to background heating, is satisfactory. For the older infant and the toddler floor warmth is desirable, and a system which sends a warm current of air underneath the floors would have some advantages. Failing this, background heating would help to prevent chills.

B. Water Heating

I. Requirements in the Home

When tenants were removed from slum conditions to new council houses, it was found that at least 75 per cent. of them " made good ". They were proud of their homes and kept them clean and bright; the sickness rates among their families diminished steadily, and the children's records of health in school and welfare centre showed a gratifying improvement.* Many analyses have been made of the causes of failure, but few have examined the reasons for the striking improvement which was so widely recognised. One of the principal reasons was the provision in the new houses of a hot water supply. For many of these tenants it became possible for the first time to have a bath into which hot and cold water ran from a pipe. Dishwashing became a relatively simple process, and house-cleaning was robbed of most of its horrors. In the slum these horrors were very real. As there was no hot water, cleaning was difficult, but it was made doubly unpleasant by the general disrepair of the houses.

The first requirement of a modern home is a good, circulating hot water system, laid on to bath, basin, and sink.

The Egerton Report recommends that the installation should be capable of supplying 250 gallons of water at 140°F. weekly. This quantity would provide enough hot water for seven hot baths a week, 10 washes a day at a basin, ample services for washing dishes and house-cleaning, as well as 50 gallons a week for laundry. These proposals represent a great advance on pre-war practice, and there is no doubt that any additional cost of installation would be well repaid in health, cleanliness and freedom from infestation.

II. Appliances to Fulfil Requirements

1. *General*

For water heating in winter a slow combustion stove in the living-room, fitted with a suitable boiler, will give excellent service. If the stove is designed with doors that can be opened when the room is in occupation, there is of course some loss of heat, but it is not difficult to organise the household arrangements to provide both services efficiently. The same stove can be used for background warming of the bedrooms. This " openable " slow combustion stove gives a higher efficiency than the open coke fire and it has the advantage of continuous operation. The open coke or anthracite fire with a back boiler retains much of the traditional appearance of the coal fire and is much more efficient. New designs give a certain amount of background heating to the house. The insulated cooking range fitted for water heating is another valuable combination, and models at low prices are now in production. When water heating and background warmth only are required, the coke or anthracite boiler in the kitchen will give continuous service; a similar installation can be used (although with greater expenditure of fuel) for full central heating by means of low pressure " radiators " or panels.

In warm weather some alternative to solid fuel appliances is essential. If there is a well-lagged storage tank of modern design, a gas circulator or an electric immersion heater can be used to supplement the solid fuel appliance, and to act in its place in summer. For less continuous use

* It has occasionally been reported (e.g. McGonigle) that owing to the high rents of new houses some families were obliged to cut down their consumption of food. The remedy is obvious.

instantaneous heaters of various types are available. Further developments in the combination of solid fuel appliances with gas or electric heating as an auxiliary may be expected.

2. *Clothes Washing*

Of all forms of heating requirements in the home the provision for washing of clothes is probably the most difficult to forecast. In Scotland there is a strong tradition in favour of the separate wash-house with double sinks, but in England hitherto clothes washing at the kitchen sink has been the rule. This system is open to many objections. It produces steam and discomfort in the kitchen and interferes with other household functions, especially in winter and in wet weather. The dampness created by washing clothes is apt to damage dry foods in cartons and to interfere with food storage generally. In some of the recent designs this nuisance is mitigated by the provision of a " utility room " in which washing can be undertaken without injury to the kitchen services; and the installation of a suitable drying cupboard helps to prevent the accumulation of wet clothing in the house. The erection of separate wash-houses adds considerably to the costs of building and heating, and also to the space requirements of each house. On the other hand, the communal laundry has not been received with great favour by the people. The " Heating of Dwellings Inquiry "* showed that 73 per cent. of the households questioned did all their washing at home, and that only a small proportion of the people who lived within ten minutes' walk from a communal laundry made use of the services available. The numbers involved were small and it is not known how many of the housewives concerned had had a sufficient period for making trial between the two methods, or whether the communal laundry was designed to secure reasonable privacy and comfort. There are well-known psychological objections to washing one's dirty clothes in public—more strongly felt in the lower than the higher income groups. The communal laundry is fairly popular in Holland, Sweden, and in some parts of U.S.A., but a great deal depends upon the type of service rendered. In a recent study of small homes in U.S.A.† it was found that 75 per cent. of the householders in the low income groups owned electric washing machines, and that home washing was the rule. In many flats and terraced houses, however, central wash-houses were provided in the basements. Occasionally these were common to a number of buildings, but rarely at a distance of more than a hundred yards from the farthest dwelling. This seemed to be about the maximum distance which people were prepared to go with their washing. Washing anywhere away from the home raised difficulties for mothers with young children.

In Sweden the large communal laundry serving a considerable number of houses is not popular. Most of the tenants have an objection to the " cubicle " method, on the ground that it does not offer sufficient privacy, and to the common use of machines on the same day on account of the supposed risks of infection, dirt transfer, and so on. Many apartment houses had a much more popular system by which each family could hire a small domestic laundry by the half-day, and so benefit by first-class machinery—the mechanical washer, the hydro-extractor, and a large drying cabinet. This method was not found to be unduly expensive, as the hire charges covered only the expenditure on fuel and power and a portion of the wages of the caretaker, who was responsible, among his other duties, for the letting of the laundry and its general supervision.

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* Egerton Report, Appendix I, Tables 63 and 67

† A Study of Heating, Cooking and Hot Water Supply to Small Houses in U.S.A and Canada. Confidential Report of a Joint Mission from the Ministry of Fuel and Powe and the Department of Scientific and Industrial Research.

C. Cooking

Requirements.—The needs of the average housewife can be stated in very simple terms: she wishes to have an appliance which—

1. is compact. There is little space to spare in the modern kitchen.
2. can boil water quickly.
3. can toast bread quickly and efficiently.
4. can, from the same source, heat the contents of a vessel rapidly or allow them to simmer gently.
5. is fitted with several heating points which may be used simultaneously, and, if desired, at varying degrees of heat.
6. can be brought into use at a moment's notice, without labour in preparation.
7. can be turned off with the minimum loss of heat.
8. has an oven which can be regulated without technical skill.
9. is safe in use, free from objectionable smell, easily kept clean.
10. is attractive in appearance, fitting in with the general design and decoration of the kitchen.
11. provides for warming plates, etc., and keeping dishes hot during the ordinary process of cooking, without expenditure of extra fuel.
12. should not require the use of specially designed saucepans, etc.
13. can heat with equal efficiency a wide range of sizes and shapes of pot, pan, or kettle.
14. should not require a large expenditure of energy, in stooping, etc.

Nearly all these requirements are fulfilled by the modern gas and electric cookers, and in rural areas, where gas and electricity are not available, the solid fuel heat storage cooker, although more expensive to instal, is economical in fuel consumption and highly efficient in operation. It is important that cooking utensils should be designed to give the highest possible efficiency with modern cookers, but this ought not to be carried to the point at which a cooker can deal with only one type of cooking vessel; this must inevitably lead to waste of heat and loss of efficiency in the homes of lower wage groups.

Where solid fuel cookers are in use, it is of course necessary to provide a flue, and this may be of some value in removing cooking smells, if a special vent is provided. It is sometimes recommended that gas and electric cookers should have a ventilating hood, but this point needs further investigation. One of the chief causes of smell in the kitchen is a deposit of small particles of cooking fats and other volatile substances on walls, ceiling, etc. The provision of a hood may actually tend to increase this nuisance by allowing heavy deposits which cannot be easily reached for cleaning.

D. Summary

Broadly speaking, the heating requirements of a house may be divided into two categories: (*a*) the needs in relation to structure and fittings, and (*b*) the conditions required for the comfort of the inmates.

In England the traditional method of space heating is to provide open fireplaces in the living-room and one or more bedrooms. In dwellings occupied to-day by the lower income groups this means in practice that a fire is maintained in one room only. The rest of the house tends to become cold and damp, affecting adversely the structure, fittings and equipment. In addition, as we have seen, the traditional type of open fire is wasteful of fuel, labour-consuming, smoke-producing and inefficient. It does not even give satisfactory warming to the room in which it is installed.

A second method of heating, which has come to be known as " background " warming, supplies warm air from a central source—an open fire or stove of special design—to various parts of the house, maintaining a moderate temperature of 50-55°F. This warmth is sufficient to prevent dampness and deterioration of structure and to enable the housewife to carry out her daily work in reasonable comfort. The central source of heat is placed in the living room as a rule, and the other rooms may be brought up, as required, to comfort temperatures by means of an auxiliary source of heat such as a gas or electric fire. If the external walls of the house have an inner lining of low heat capacity and low transmittance, this form of intermittent heating (known as " topping up ") provides comfort conditions rapidly and economically. It is suggested that this method is specially suitable for space heating of houses in our variable climate.

The third method of heating, widely employed in countries where long spells of cold weather occur, is full and continuous space heating of the whole house from a central (or district) source. This is generally provided by a stove which heats water which is circulated through low pressure " radiators "; but recently air heating up to comfort temperatures has been used to an increasing extent. The objections raised to full central heating are that it is unnecessarily expensive in our climate, and that overheating of houses during mild spells is likely to occur, unless there is good thermostatic control. On the other hand it must be admitted that full central heating, whether district or individual, has not yet received sufficient trial in low cost houses in this country. Investigation and experiment on a considerable scale are urgently required.

APPENDIX IV

DOMESTIC ELECTRICITY TARIFFS

Report by the Economists' Sub-Committee

(Mr. Geoffrey Crowther and Professor John Jewkes, C.B.E.
Assessor, Mr. P. Chantler.)

Electricity is sold both for uses in which it has little or no competition to meet—lighting, radio, and small power supplies—and for uses in which it must face strong competition—particularly in heating. To meet these diverse market conditions electricity is sold under characteristic tariffs, with different charges for different uses. It has been asserted that, while charging a relatively high price in those sectors of the market where there is no effective competition and the service has a high value to consumers, electricity supply undertakings charge in competitive sectors rates which are so low as to be " uneconomic." It is held that such a policy is unfair to competitors who are up against " dumping " prices; unfair to other consumers who have to " carry " or " subsidise " the favoured users; and unfair to the community, involving a waste of coal and other resources, because the service could have been given at lower real cost by another fuel.

In the domestic fuel market, it is said that the large revenue obtained from relatively high rates charged for lighting enables supply undertakings to subsidise sales under the " all-in " tariff for extended use, and that this policy of uneconomic rates prejudices the hold of the gas industry on the domestic cooking load, which is the main source of its revenue. The suggestion that their charges are uneconomic is as vigorously denied by the electricity industry (whose view is supported by the Electricity Commissioners) as it is advanced by the gas industry.

What are the facts about this situation? There is no doubt that a high degree of price differentiation does exist. It has been the usual policy of

electricity supply undertakings to maintain a charge of 4d. (or more) per unit for lighting while current is supplied under the domestic two-part, or "all-in," tariff at a running charge of about ½d. a unit—a policy which has been recommended to the industry as the best way to extend the domestic use of electricity. The existence of a standing charge in the two-part tariff does not affect this comparison because this charge is approximately covered by the saving which the consumer—who will use electricity for lighting and radio in any case—makes by avoiding the high flat rate lighting charge, when he adopts the tariff. As the Electricity Commissioners have stated in evidence before the Council "even if gas is used for all heating purposes, a sum approximately equal to the fixed charge would be payable for the electricity required for lighting, wireless and vacuum cleaner."

This point may best be illustrated arithmetically. A typical electricity supply undertaking would offer, in 1938, electricity to domestic consumers living in low cost houses at a flat rate of 4d. per unit, or on a two-part tariff with a standing charge of about 50s. p.a. and all current consumed at ½d. per unit. If the consumer were to use current for lighting and radio only, consuming (perhaps) 180 units p.a., this would cost him, under the flat rate, 180 × 4d. = 60s. If, however, he chose to adopt the two-part tariff, the same consumption would cost him the standing charge, 50s., plus 180 × ½d. (= 7s. 6d.), giving a total bill of 57s. 6d. It therefore just pays him to adopt the tariff for his lighting and radio alone, and all extra current, whether for cooking or other domestic uses, only adds ½d. per unit to his bill.

It might be that his annual consumption on the flat rate for lighting and radio use would be substantially less than 180 units p.a. and part of the two-part tariff standing charge could not be carried by this load. This excess would be small, but it would raise the incremental cost for extended use above ½d. per unit. It remains true, however, to say that electricity for domestic cooking is sold at a quarter or less of the price charged (in fact if not also in form) for lighting.

It is this wide differentiation which has given rise to the assertion that domestic electricity tariffs are "unfair," not only to the consumer of electricity for lighting and radio only, but also to the gas industry, which must compete for and largely depends on the cooking load, but cannot compete effectively for lighting and not at all for radio.

It is impossible to say, in a precise figure, what is the cost of any particular part of the total supply of electricity. It is possible to give a figure for the average cost per unit of the total supply as a whole, and many people are inclined to argue that any supply that is sold below this figure is sold "below cost." But this is not necessarily so. For instance, most electricity is consumed during the waking hours and not in the middle of the night, and if the equipment for generation and distribution already exists to supply these waking-hour needs, the "cost" of supplying current to an immersion water heater that is only switched on at night is obviously very small. Nor is it unfair to other users to supply current at cheap rates for such a purpose, since if the rate charged produces anything more than the bare cost of keeping the generator running all night, it is making some contribution to the revenue of the undertaking and helping to reduce the charges made for other uses.

This is a simple illustration of the "marginal cost" theory—that is, that the rate charged for any load should be at least equal to the marginal costs involved in supplying that load, the marginal costs being the costs that have to be met in supplying that particular load over and above the costs that the undertaking would have to meet in any case, even if that load did not exist. The nearest that it is possible to approach to a statement of absolute validity is that **a rate which does not cover at least the marginal costs of providing the load to which it is applied is an uneconomic rate.**

It should, however, be observed that this statement contains a double negative and the words " at least." It does not follow that a system of rates which exactly covers the marginal costs is economic. If an undertaking charged rates exactly equal to the marginal costs of *each* type of load, it might very well not cover its total costs, since each load would be paying for the specific costs for which it alone was responsible, and none of them would be making any contribution towards the general costs for which they were collectively responsible. The marginal cost principle is thus very far from being a complete guide to rate-making. It does no more than fix the lower limit of the range within which the correct rate for each type of load must lie. Nevertheless, it does provide a starting point for answering the question with which we are concerned. The starting question is whether the rates charged for cooking were, before the war, below the marginal cost of supplying electricity for cooking.

Unfortunately, the question is easier stated than answered. To estimate revenues received is not difficult: this, however, cannot be said of the problem of determining the marginal costs of a particular load.

To discuss this latter problem requires an analysis of the costs involved in supplying electricity. There is some degree of arbitrariness about any such analysis: the boundaries are never clear, and they shift according to the width of output variation and the length of time under consideration. It is, nevertheless, an essential step in dealing with the economy of tariffs, and, subject to this qualification, they may be sub-divided into the following four* groups:—

(1) *Energy or running cost.*—This means the direct expenditure incurred in supplying the actual current from any existing and operating system. It consists mainly of the cost of coal burnt and lubricating oil used in the generating station but it also includes whatever part of labour, repair, and maintenance costs is taken as varying with the amount of current being supplied at any time.

(2) *Capacity Costs.*—These are mainly charges for interest and depreciation on capital equipment for generation, transmission and distribution.

(3) *Consumer costs.*—These are costs which are incurred merely through the existence of the consumer on the books and mains of the electricity supply undertakings: they accrue whether he takes any current or not in a particular accounting period.

(4) *General overhead expenses.*—These are all those cost items which can be directly related neither to the amount of current generated, the amount of capital equipment required, nor the number of consumers, at a particular time, but are incurred by the existence of the supply undertaking as such.

Each *load,* to be economic, should cover the costs to which it gives rise under (1) and (2). Each *consumer* should cover (3). But (4), general overheads, are common costs for the allocation of which there is no theoretically " just " or " correct " method. In practice, these costs tend to be distributed on the basis of " what the traffic will bear ". It would be possible to work out some method for the allocation of common costs which would be accepted as appearing equitable, but this would in reality be a purely pragmatic exercise.

Thus the question whether a tariff is economic or not turns on whether the load served under it provides sufficient revenue to cover the energy or running costs, in respect of the current taken, and the capital costs on any generation, transmission and distribution capacity for whose installation and maintenance this load must be held responsible, i.e., which it is necessary to have in order to supply this load, but which would not otherwise be needed at all.

* One might also add a fifth group: *utilisation appliance costs.* It is sometimes alleged that electricity supply undertakings sell or hire cookers at less than their actual costs. If this is so, the load supplied through these appliances, to be economic, should also provide enough revenue to cover any such deficiency.

The first category is relatively simple. It is possible easily to determine (within limits) what the *energy cost* amounts to. The Electricity Commission's Annual Returns relating to all authorised electricity undertakings show that the average cost of energy had, before the war, fallen to less than ¼d. per unit sold, and was still falling, despite a small increase in the cost of coal.

But the second category, the determination of capital costs in respect of generation, transmission and distribution capacity *attributable to a particular load,* presents very great difficulty for the simple reason that *different* loads largely employ the *same* capital equipment at different times. The problem therefore becomes mainly one of sharing out costs which are incurred in common. The " correct " allocation of capacity costs has been examined (although the basic factual data are elusive) by many people for a long time, and they have advanced many possible solutions, no one of which, from the economic point of view, can be considered " correct " to the exclusion of all the others, for the reason that economic analysis gives no positive guide to the allocation of common costs.

It is possible, however, to take what might be called a " minimum " view of the capital costs attributable to any particular load by considering the extra demands it places on the generation, transmission and distribution equipment at the *time when they are fully loaded,* and when, therefore, the particular load under consideration cannot be met from capacity installed to meet other loads, but not at the time in use. This is really the marginal cost theory again, considering only the difference that is made to the total capacity costs of the undertaking by serving the load in question. It takes into account only the costs of that capacity which cannot be shared with other loads, and as this capacity consists only of that which has to be installed to meet the peak load on the supply, this method of cost allocation is usually called the " peak responsibility " system. To determine the marginal capacity cost of a particular load, in short, it is enough to ask what is its claim on capacity at the time of the total peak load. The difficulties are in the first place to find what any particular load amounts to at the time of the undertaking's peak load, and in the second place the fact that the peak load itself is liable to shift. Any definite attribution of capital cost responsibility can only be a guess, with limited data as a guide, at what happens at a particular point in time.

Despite these difficulties and limitations it is possible to reach some very broad and tentative conclusions. In typical urban areas before the war, at the time of the peak on the system as a whole, which occurred on a late winter afternoon, the average cooker was consuming about 0.2 kW, according to evidence which has been submitted to the Council by the Electricity Commissioners. The annual capital cost in respect of generation, transmission and distribution as shown in the pre-war Annual Return published by the Electricity Commission was about £5 per kW. Thus, at that time and on the " peak responsibility " theory of cost allocation the " capacity cost " of supplying electricity for cooking was some 20s. per annum per cooker, or somewhat less, when account is taken of the existence of " diversity " between the time of the afternoon peak as between different undertakings and different parts of the country. The current for cooking was supplied in the domestic " all-in " tariff at a typical price of about ½d. per unit; the average annual consumption was about 1,000 units per cooker. The energy cost, as noted above, was something under ¼d. per unit sold, leaving an average contribution to capital costs of 1,000 by ¼d. equals 20s. 10d. a year, so that the electric cooking load, on these estimates, appeared just about to cover its marginal capacity costs, and could not be proved to be an uneconomic load.

In the typical case, therefore, the electric cooking load was probably not sold below marginal cost before the war. But the fraction by which this

conclusion is reached is a small one, and it might well be upset by a comparatively slight change in the circumstances. And there may well be several changes in the circumstances after the war—apart from the general rise in costs, which we assume will be met by an equally general rise in rates charged for all purposes.

The question really turns on what happens to the capacity costs due to electric cooking. Before the war, the average load per domestic cooker at the time of the system peak might amount to no more than 0.2 kW per cooker, but this might rise very much higher after the war, for the following reasons:

(1) Before the war, it appears that a great many electricity (and gas) cookers were used as ancillaries to coal ranges, and were mainly in service when the coal range was not—during the summer months. But summer electricity loads have no marginal capacity costs, because about half the plant is then out of use, being needed only in winter: the more electric cookers were used in this way, the less, therefore, would be their average capacity cost. After the war, however, partly because of the increased cost of coal, and partly because most newer houses are not designed to duplicate cooking appliances, a higher proportion of electric cookers are likely to be used for year-round service, and this will increase their average capacity cost, perhaps very appreciably, above that of the 0.2 kW quoted above. There would, of course, be some contribution from the extra units sold for cooking towards meeting this extra capacity cost. But that contribution would be small. On the extra 500 units which might be taken, it would amount to only 8s. 4d. per annum, assuming as above a contribution of $\frac{1}{4}$d. per unit, whereas the extra capacity costs might be much greater.

(2) It is possible that, independently of what happens to the cooking load, the peak load on the system may remain, as in wartime, at 8.0-9.0 a.m. rather than shift back to its usual pre-war position of 4.30-5.30 p.m., or it might be that the morning and evening peaks would become of about equal size, so that any " peak responsibility " theory of cost allocation would really have to consider them both. This consideration is not purely hypothetical: it has recently been investigated by a Committee including men from various sections of the electricity supply industry, which finds the conventional " peak responsibility " theory of cost allocation " altogether inadequate " in modern conditions, and holds that capacity costs throughout a winter working day should be taken into account.* But the average cooker load at 8.0-9.0 a.m. may be higher, even assuming pre-war patterns of use, than at 4.30-5.30 p.m., so that on the " potential peak responsibility " theory, advocated by this Committee, the relevant capacity cost might be much more than that of 0.2 kW., and, to be economic, the tariff would need to be increased.

(3) If a very great expansion of electric cooking took place, *without* a proportionate expansion of other major loads on the system, it might be that the system's peak load itself would become largely made up of cooking. It has been estimated that the load of the average cooker, at the time of the total maximum cooking demand which occurred on Sunday mornings (as distinct from the total peak load on the system), amounted before the war to about 1 kW. If this load occurred at the time of (and was largely responsible for) the system peak, it is clear that, under " peak responsibility " cost allocation, the electric cooking load would become responsible for capacity costs five times as great as before the war. It is very unlikely, however, that so extreme a position would develop, because other loads will certainly expand in future, as they have in the past. But some increased capacity cost might

* " An improved method for allocating to classes of consumers the demand portion of the standing cost of electricity supply "—The British Electrical and Allied Industries Research Association, Technical Report, Ref. K/T. 109.

arise as the cooking load developed and in such conditions tariffs such as the typical one quoted might not be economic.

Our general conclusion is this. We cannot say that, in the typical case, electricity was sold before the war for domestic cooking at uneconomic rates. But, on the other hand, the contribution above marginal costs from this load was probably small. In particular cases it may have been negative, and in some circumstances such instances might become more usual in the future.

Moreover, the extent of the conclusion reached should be remembered. It has only been established that the rates charged for cooking before the war could not be proved to be uneconomic. It has not been positively proved (and in the nature of the case cannot be proved) that they were in fact making what a reasonable man, with access to all the facts, might judge to be a fair contribution to the general costs of the electric supply industry. Indeed, since what remains of the typical charge after meeting the marginal costs is so very small, there might be held to be a *prima facie* presumption that these rates were not making a fair contribution. But that would be an expression of judgment, not a matter of fact. And it might further be that a relatively small increase in the typical rate (say from $\frac{1}{2}$d. to $\frac{5}{8}$d. per unit) would increase the contribution to general costs to an adequate level.

Our conclusions are, therefore:

(i) that before the war, as a general matter, the typical rate charged under an " all-in " tariff for cooking by electricity covered the marginal costs of supplying electricity for cooking and made a small contribution towards meeting the general expenses of the industry;

(ii) that these rates cannot therefore be proved to have been uneconomic;

(iii) but that the circumstances may be different in the post-war period and that the rates charged for cooking might have to be raised relatively to other rates (e.g. that for lighting) to cover marginal costs;

(iv) and that it is impossible to prove whether or not the contribution made by the cooking load to the general revenues of the industry was large enough, but that in any case it was small.

APPENDIX V

DEFINITIONS

Board of Trade Unit (referred to as " unit ") is the electrical unit of energy. It is the commercial unit for purposes of public supply and is the product of time measured in hours by the power measured in Kilowatts. Thus:

1 unit = 1 Kilowatt-hour = 1,000 Watt-hours.
1 Kilowatt-hour = 3,413 B.Th.U.

To avoid confusion where quantities of different fuels are being compared in the Report the electrical unit is described as " 1 Kwh."

British Thermal Unit. One British Thermal Unit (B.Th.U.) is the amount of heat required to raise the temperature of 1 lb. of water by 1° F.

Building Owner. This term is used to describe the person or authority who places a contract for the house.

Calorific Value of a fuel is the amount of heat given out when a specified quantity of the fuel is completely burnt. For coal it is usually expressed as the number of B.Th.U. per lb. and for gas as the number of B.Th.U. per cu. ft.

Domestic Consumption. In using this term we refer to disposals to domestic consumers including, in the case of coal and coke, disposals to

shops, offices and other establishments, partly or entirely non-residential, with an annual consumption of less than 100 tons of coal and/or coke per annum, and including miners' coal. (See note at beginning of Appendix I.)

In the case of gas and electricity the domestic use includes lighting, but excludes disposals to shops, offices, etc., where the use is mainly for lighting.

Domestic Heating. Throughout this Report the word " heating " denotes, where the text demands, not only room warming (also referred to as space heating), but also water heating, cooking and auxiliary services such as clothes washing.

Efficiency.

(a) **Production Efficiency** means the overall efficiency of the conversion of coal into gas, coke or electricity and of the distribution of these fuels to the consumer's home. It is measured by the ratio of the sum of the thermal values of the products sold for use external to an electric power station or gasworks to the potential heat in the coal consumed, and is expressed as a percentage. (See Egerton Report, Section 6.1.1.)

Table V of Appendix I shows production efficiencies obtained in the carbonising process and in electricity generation and distribution.

(b) **Test Bench Efficiency** is defined as the ratio of the heat output of an appliance under optimum conditions in the laboratory to the thermal equivalent of the energy or fuel delivered to the appliance. (Egerton Report, Section 6.1.2.)

(c) **Working Efficiency** is the ratio of the heat usefully employed when the fuel is used in an appliance under average conditions to the thermal equivalent of the energy or fuel delivered to the appliance.

It should be noted that we use the term " working efficiency " in a different sense from that in which the Egerton Committee used the term " appliance efficiency " (Egerton Report, Section 6.1.5.). Our term takes account of loss of efficiency due to unscientific use by the householder, whereas the Egerton Report's use of the term " appliance efficiency " does not.

(d) **Coal Economy Efficiency** is the ratio of the usefully employed heat output of an appliance under normal domestic conditions to the total heat content of the coal used, whether burnt in the appliance or used in producing the gas, coke or electricity consumed in the appliance. (See Egerton Report, Section 6.2.1.)

Examples of the various efficiencies are given in Table VI of Appendix I.

Heating.

(a) **Background Heating.** The maintenance of a moderate temperature in a dwelling throughout the 24 hours, this temperature being generally below the comfort requirements for sedentary occupation.

Topping Up. The provision of extra heat to bring a room to a comfortable temperature during periods of occupation.

(b) **Central Heating.** The provision of heat from a single source capable of maintaining a comfortable temperature in a dwelling throughout the 24 hours—i.e., so that no topping up is needed during periods of occupation of any room.

(c) **Convection Heating.** By this we mean the distribution of heat by air which has itself been warmed by passing over heated surfaces.

(d) **Radiant Heating.** The transmission of heat from a hot surface by radiation.

The term **" Radiator "** is used in this Report for systems of pipes or panels heated by hot water or steam from which heat is given to a room: in practice most of the heat transferred from such a system is by convection rather than radiation. (See Chapter IX, Section 4 (*a*).)

Alternatively the term is used to describe the forms of electric fires in which the heating elements are visible. (See Chapter III, Section 2.)

Off Peak Supply is supply at periods other than the period of maximum demand.

Therm. 100,000 B.Th.U.

Useful Heat means the heat available for use, measured in units appropriate to any fuel, after allowing for heat losses in production, distribution and utilisation. (See Table III of Appendix I.)

APPENDIX VI

I. ORGANISATIONS AND PERSONS FROM WHOM WRITTEN AND ORAL EVIDENCE WAS TAKEN

Organisations, etc.	Representatives
British Coal Utilisation Research Association and The Coal Utilisation Joint Council.	Mr. Robert Foot, O.B.E., M.C. (President of B.C.U.R.A. and C.U.J.C.). Mr. John Charrington (Vice-President of C.U.J.C.). Mr. J. Stanleigh Turner, J.P. Mr. S. McEwen. Professor D. T. A. Townend, D.Sc., Ph.D., D.I.C., F.R.I.C. (Director of B.C.U.R.A.). Mr. J. S. Hales (Principal Scientific Officer, B.C.U.R.A.). Mr. J. S. Williams (Secretary, C.U.J.C.). Mr. R. Colville-Wallis (Development Officer, B.C.U.R.A.).
Central Electricity Board	Mr. Harold Hobson, B.Sc., M.I.C.E., M.I.E.E. (Chairman). Sir Johnstone Wright, M.I.C.E., M.I.E.E. (General Manager).
The Coal Industry and Coal Distribution.	Mr. J. Stanleigh Turner, J.P. Mr. G. C. M. Jackson. Mr. John Charrington.
The Combustion Appliance Makers Association.	Mr. S. McEwen (President). Mr. W. Rennie (Chairman, Domestic Heating Section). Mr. S. G. Fiedler. Mr. L. J. King. Mr. P. A. H. Elliot (Director).
The Electricity Commission	Sir Cyril Hurcomb, G.C.B., K.B.E. (Chairman). Sir John Kennedy, O.B.E. (Deputy Chairman). Sir Leonard Pearce, C.B.E., D.Sc., M.Inst.C.E., M.I.E.E.
Fuel Efficiency	Dr. E. S. Grumell, C.B.E., M.I.Min.E. (Chairman of Fuel Efficiency Committee, Ministry of Fuel and Power). Mr. W. A. Macfarlane, B.A., B.Sc., Ph.D. (Director of Fuel Efficiency, Ministry of Fuel and Power).
Gas Advisory Committee	Mr. A. E. Sylvester, F.C.A. (Chairman). Mr. E. V. Evans, O.B.E., D.Sc., F.I.C., M.Inst.Gas.E. Mr. A. W. Smith, C.B.E., F.C.I.S. Mr. S. E. Whitehead, J.P., B.Sc., M.Inst.C.E., M.Inst.Gas.E. Mr. W. J. Smith (Secretary).

Organisations, etc.	Representatives
The Gas Research Board	Mr. E. V. Evans, O.B.E., D.Sc., F.I.C., M.Inst.Gas.E. (Chairman). Mr. F. J. Dent, D.Sc., Ph.D., M.Inst.Gas.E. (Assistant Director). Mr. T. C. Finlayson, M.Sc., M.Inst.Gas.E., M.I.Chem.E. Mr. H. Hartley, D.Sc., M.Inst.Gas.E., M.I.Chem.E. Mr. C. A. Masterman, M.A., M.I.Mech.E., M.Inst.Gas.E., F.R.I.C. Colonel H. C. Smith, C.B.E., D.L., J.P., M.Inst.C.E., M.Inst.Gas.E. Professor D. T. A. Townend, D.Sc., Ph.D., D.I.C., F.R.I.C. Mr. S. E. Whitehead, J.P., B.Sc., M.Inst.C.E., M.Inst.Gas.E.
The Incorporated Association of Electric Power Companies.	Mr. H. Richardson (President). Mr. W. N. C. Clinch, M.I.E.E. Mr. Leonard Howles. Mr. J. A. MacKerrell (Secretary).
The Institute of Petroleum	Mr. T. F. Laurie. Mr. C. T. Brunner. Mr. R. J. Bressey. Mr. J. S. Jackson. Mr. G. R. Llewellyn. Mr. G. Richardson (Secretary).
The Joint Committee of Electricity Supply Organisations.	Mr. A. J. Fippard (Chairman). Mr. Leslie Gordon (Vice-Chairman). Mr. J. W. J. Townley, A.M.I.E.E. Mr. J. Eccles, B.Sc., M.I.E.E., A.M.Mech.E. Mr. W. P. Lilwall, M.I.E.E. Mr. J. W. Leach, A.M.I.E. Mr. H. F. Carpenter (Honorary Secretary). Mr. E. G. Baker (Joint Secretary).
National Smoke Abatement Society.	Mr. Charles Gandy (President). Mr. Arnold Marsh (General Secretary).
Solid Smokeless Fuels Federation.	Colonel H. C. Smith, C.B.E., D.L., J.P. (Chairman). Mr. G. E. Aeron Thomas, O.B.E., D.L., J.P. (Chairman). Mr. Leslie O'Connor (Director). Mr. W. L. Boon, O.B.E. Mr. P. E. Holden.

II. PERSONS FROM WHOM ORAL EVIDENCE WAS TAKEN

Sir Alfred Egerton, F.R.S., F.I.C., F.Inst.Phys., Chairman, Heating and Ventilation (Reconstruction) Committee of the Building Research Board, D.S.I.R.

Sir Charles Reid, M.I.Min.E., Director of Coal Production, Ministry of Fuel and Power.

III. PERSONS WHO SUBMITTED WRITTEN EVIDENCE, BUT WHO WERE NOT HEARD ORALLY

Colonel Whiston A. Bristow, M.I.E.E., M.I.A.E., F.R.Ae.S., F.Inst.F., Chairman and Managing Director, Low Temperature Carbonisation Ltd.

Mr. W. McGilvray, C.B.E., Powell Duffryn Ltd.

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